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# ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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(Branch of Agricultural & General Engineers, Ltd.)
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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 33 and 96.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 7179

**Bristol Pneumatic Tools.**
ROCK DRILLS. LTD.
See Advertisement last week, page 11.

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HYDRAULIC and HAND,
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GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 8307

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BIRMINGHAM. 8303
See Advertisement last week, page 119.

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MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9983

**Tank Locomotives.**
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7260

**Cochran Boilers.**
MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 8305

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Manufactured by 3591
PETTERS LIMITED, Engineers, Yeovil.

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Sole Makers:
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*See page 15.* 7454

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*BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester.* Od 9753

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S. H. HEYWOOD & CO., LTD., 8143
REDDISH.

**Fuller, Horsey, Sons & Cassell,**
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY 1834
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ENGINEERING WORKS.
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**Tubes and Fittings.**
6990
**The Scottish Tube Co., Ltd.,**
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 99, Feb. 20.

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SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
**Repairs on Pacific Coast**
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Worm Wheels cut up to 13 ft. diam.
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**Yachts, Launches, or Barges,**
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

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write
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*Systems*
PRESSURE, AIR, STEAM.
*For Boilers of all types.*
KNRMODES LIMITED,
35, The Temple, Dale Street, Liverpool; and
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*Naval Outfits a Speciality.*
4078

**Locomotives Tank Engines**
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 137, last week.
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to the
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(UP TO 35 TONS.) 8143
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"APTOL" 7184
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**Henry Wells Oil Co.,**
11, HAYMARKET, S.W.1.

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**Railway Wagon Couplings**
and GENERAL SMITHY WORK,
write 8184
WELDLESS CHAINS, LTD., Coatbridge.

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GENERAL CONSTRUCTIONAL ENGINEERS,
**Boilers, Tanks, & Mooring Buoys**
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**Tubes and Fittings.**

**Stewarts and Lloyds, Ltd.,**
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See Advertisement page 75. 8167

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for Chemical Wks., Mineral Water Mfrs., Breweries, and all other purposes. — SPARKLETS AND GENERAL MFG. CO., Ltd., Edmonton, London, N. 18.

**Die Finished Castings**
ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to SPARKLETS AND GENERAL MFG. CO., Ltd., Edmonton, London, N. 18.
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**Steel Castings.**
8181
See displayed advertisement every alternate week.
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**The Glasgow Railway Engineering Company,**
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London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
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Address, BURNETT AVENUE, HULL.
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**Augustin-Normand**
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Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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**Rubber Hose** Steam and Air Drill
GUTTA PERCHA & RUBBER, LIMITED,
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S. H. HEYWOOD & CO., LTD.,
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**R. Y. Pickering & Co., Ltd.,**
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
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London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 8383

**Diesel Driven Generators,**
400-500 Kw., D.C., 460 or 250 Volts, 250 R.P.M., in excellent condition. Low price. Engines and Dynamos could be sold separately. Also TWO 850 Kw. Parsons TURBINES, 230-250 Volts, D.C. (in series 460-500 volts), complete with Spare Armature and Condenser.
Exhaust TURBINE SET, Willans-E.C.C., 200 Kw., 440/500 Volts. Complete with Condenser, Pumps, &c.
JENNINGS,
West Walls, Newcastle-on-Tyne. 7969

**Royles Limited,**
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES. } Row's Patents
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS
WATER SOFTENING and FILTERING. 8128

**Yarrow Patent Water-tube Boilers.**
7748
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

**Matthew Paul & Co., Ltd.**
LEVENFORD WORKS, **Dumbarton.** 7689
See Full Page Advt., page 74, Feb. 6.

**Forgings.**
**Walter Somers & Co., Ltd.,**
HALESOWEN. 7216

**Head, Wrightson & Co.,**
LIMITED.
See Advertisement page 95. 3403

**Taylor & Challen Presses.**
8196
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Feb. 6.

**Railway Switches and Crossings.**
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 7903

**Measuring Machines**
FROM
**Stock.**
THE
**Newall Engineering Co.**
(Proprietors, Peter Hooker, Ltd.),
LONDON, E. 17. 7934

**Machine and Engineering**
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT AUT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

**Locomotive Traversers**
(ELECTRIC). 8143
S. H. HEYWOOD & CO., LTD.,
REDDISH.

**Dredging Plant**
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
**Werf Conrad,** HAARLEM, HOLLAND,
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
*See half-page Advert. last week and next week.* 7538

**Centrifugals.**
**Pott, Cassels & Williamson,**
MOTHERWELL, SCOTLAND.
7862
See half-page Advertisement page 38, Feb. 20.

## The Manchester Steam Users' Association

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mosley Street, Manchester.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

## The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. C 508

If communications to—
H. W. RHID, General Secretary.
Head Offices—
81, High Holborn London, W.C.1.

## Royal Show, Darlington.

JUNE 29th to JULY 3rd, 1920.

EXHIBITION OF IMPLEMENTS, &c.

The Regulations and Forms of Application for Space are now ready.

Applications must be made by SATURDAY, MARCH 20th, 1920.

TRIALS OF AGRICULTURAL TRACTORS AND PLOUGHS.

Commencing September 28th, 1920.
Entries close March 20th, 1920.

Live Stock and Forestry Entries close on MAY 20th; Poultry, Rabbits, Cavies, Produce, Horticultural Exhibition, and Plantations Competitions on MAY 31st; Cider and Perry Entries close on MAY 1st.

THOMAS McROW, Secretary.

Royal Agricultural Society of England,
16, Bedford Square, London, W.C. 1.
January 1920. D 840

APOLOGY.

## Our Attention has been Drawn

by Messrs. J. Hopkinson & Co., Ltd., of Huddersfield, to the use in our 1914 Catalogue of the word "Platnametal" which closely resembles their registered trade mark "Platnam" Metal.

We were unaware that that mark was already in use, and have withdrawn ours, and express our regret to Messrs. Hopkinson.

S. DIXON & SON, Ltd.,
Swinegate, Leeds.
D 843

## Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434, Offices of Engineering.

## Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all Engineering Exams. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8–10, Trafford Chambers, 58, South John Street, Liverpool. 8421

## Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Course may commence at any time.—39, Victoria St., Westminster, S.W. 8394

## Engineering Special Classes.

Marine & Aero-Engines, Alternating Currents. Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 384, Oxford Rd., Manchester.


## TENDERS.

COUNTY BOROUGH OF SALFORD.

## The Electricity Department

have FOR SALE one 1000 kilowatt Direct Current TURBO-GENERATOR, Williams Parsons type, coupled to Brown-Boveri Generator, voltage 460-485, rated output 1000 kilowatts, with 180 lbs. steam pressure. The Set is in regular commission and can be seen in operation by appointment. Full particulars from the Borough Electrical Engineer, Electricity Works, Frederick Road, Salford. Tenders are invited not later than Twelve noon Monday, March 1st, 1920.

L. C. EVANS,
Town Clerk.
D 787

EDINBURGH CORPORATION.

ELECTRICITY SUPPLY.

The Lord Provost, Magistrates and Council invite

## Tenders for the following

WORK:—

Specification No. 37, for CONDENSING PLANT for Portobello Station.

Copies of the Specification, Form of Tender and Drawings, can be obtained from the ENGINEER, Dewar Place, Edinburgh, on and after 3rd March, upon payment of a deposit of £3 3s. for the Specification. An additional copy of the Specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned upon receipt of a *bona fide* Tender and on return of the Specification and Drawings.

The Specification and Drawings can be seen at, but not obtained from, the Offices of Sir Alex. B. W. Kennedy, 17, Victoria Street, Westminster, London, S.W.

Tender, on the prescribed form, enclosed in sealed envelope and endorsed on the outside, "Electricity Supply—Tender for Specification No. 37," must be delivered at the office of the undersigned, not later than 10th March, 1920, at 10 a.m.

The Council do not bind themselves to accept the lowest or any offer.

A. GRIBBSON, S.S.C.,
City Chambers, Edinburgh, Town Clerk.
23rd February, 1920. D 903

H.E.H. the NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Directors of the above Company are prepared to receive

## Tenders for the Supply of:—

70,000 TRANSVERSE STEEL SLEEPERS,
and
308,000 STEEL KEYS for same,

in accordance with the Specification to be obtained at the Company's Offices for the sum of 10s. 6d., which will not be refunded.

Tenders to be addressed to the Secretary, marked "Tender for Sleepers," and to be delivered at the Company's Offices not later than Noon on Friday, the 5th March, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

F. ADAMS,
Secretary.

Offices of the Company,
50, Old Broad Street,
London, E.C. 2.
23rd February, 1920. D 873

THE URBAN DISTRICT COUNCIL OF ABERDARE.

TRAMWAYS.
STEEL RAILS, PERMANENT WAY CONSTRUCTION, &c.

The Tramways Committee are prepared to receive

## Tenders for the Reconstruction

of existing Tramways and for New Tramways.

Copies of the Conditions of Contract, Specifications, Form of Tender and Quantities may be obtained from Mr. H. M. Lacey, No. 12, Victoria Street, Westminster, S.W. 1, on and after Wednesday, the 3rd March, on payment of a deposit of £5 5s. 0d., which will be returned on receipt of a bona fide Tender.

Tenders to be addressed to the Clerk to the Council, at his offices, Town Hall, Aberdare, and to be received not later than noon on Saturday, March 20th, endorsed "Tender for Tramways."

The lowest or any Tender will not necessarily be accepted.

W. R. MORGAN,
Clerk.
D 918

TO ENGINEERS AND OTHERS.

The Metropolitan Asylums Board invite separate

## Tenders for:—

(a) PROVIDING and FIXING a NEW FUEL ECONOMISER,
(b) BUILDING BRICKWORK SETTING for Fuel Economiser, at Joyce Green Hospital, Dartford, Kent,

each in accordance with Drawing and Specifications prepared by Mr. T. Copper, M.Inst.C.E., M.I.Mech.E., Engineer in Chief.

The Drawing, Specifications and Forms of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m., on Monday, 1st March, 1920, and the Drawing, Specifications and Forms of Tender can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specifications and the Drawing have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board, not later than 2.30 p.m., on Wednesday, 17th March, 1920.

By Order,
DUNCOMBE MANN,
Clerk to the Board.
D 879

CITY OF BIRMINGHAM WATER DEPARTMENT.

COVERED SERVICE RESERVOIR AT HIGHTER'S HEATH, YARDLEY WOOD.

The WATER COMMITTEE of the CORPORATION OF BIRMINGHAM are prepared to receive

## Tenders from Competent

persons willing to enter into a contract for the COMPLETION of the COVERED RESERVOIR and CONNECTIONS at Highter's Heath, Yardley Wood, in the City of Birmingham.

The Drawings may be seen and Specifications and Bills of Quantities obtained at these offices on and after Wednesday, 3rd March next, on the deposit of the sum of £5 which will be returned after the receipt of a *bona fide* Tender with the Bills of Quantities fully priced out. Tenders must be based upon the Drawings, Specifications and Estimates provided. Persons tendering will be required to quote for a quantity of material already on the ground as set out in the Specification.

The site at Highter's Heath may be inspected at any time by appointment.

Early application for particulars is necessary as only a limited number of Specifications will be issued, and none after Monday, 15th March, 1920.

The Contractor will be required to undertake not to pay less than the minimum standard rate of wages current in the district in which the works are situate.

Sealed Tenders addressed to me, and endorsed "Tender for the Completion of Highter's Heath Reservoir," are to be delivered at these offices at or before noon on Monday, 29th March, 1920. The Corporation do not bind themselves to accept the lowest or any Tender.

B. ANTONY LEES,
Council House, Secretary.
Edmond St., Birmingham,
February 25th, 1920 D 963

## APPOINTMENTS OPEN.

## A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering

## Wanted, Thoroughly Qualified

WHOLE-TIME TEACHER of Metalwork, Mechanics and Machine Drawing. Commencing salary £300 per annum, plus allowance for previous experience, rising to £400 per annum according to scale.

Application Forms may be obtained from J. RAGLES, Principal, Technical College, Doncaster. D 791

STAFFORDSHIRE EDUCATION COMMITTEE.

## Applications are Invited for

the POST of HEAD of the ENGINEERING DEPARTMENT, County Technical College, Wednesbury, at a salary of £500.

Further particulars and forms of application, which must be returned before MARCH 3rd, may be obtained from the undersigned.

GRAHAM BALFOUR,
Director of Education.

County Education Offices,
Stafford.
February, 1920. D 385

CITY OF LINCOLN
MUNICIPAL TECHNICAL SCHOOL.

A. E. Collis, M.I.M.E.—Principal.

## Applications are invited for

the POST of ASSISTANT LECTURER in the Mechanical Engineering Department.

Candidates will be required to take day and evening classes. University degree or equivalent qualification. Works' experience and Laboratory Practice essential.

Commencing Salary £275–£325 according to experience and qualifications rising by annual increments of £12 10s. to £400.

Form of application and further particulars may be obtained from the PRINCIPAL to whom applications should be returned not later than March 20th, 1920. D 746

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.

APPOINTMENT OF A LECTURER IN MATHEMATICS.

The Governing Body invites

## Applications for a Lectureship

IN MATHEMATICS in the College of Technology.

Salary £500 per annum.

Conditions of appointment and form of application may be obtained from the REGISTRAR, College of Technology, Manchester. The last day for the receipt of applications is Monday, 15th March, 1920.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment. D 836

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.

APPOINTMENT OF AN ASSISTANT LECTURER IN PHYSICS.

The Governing Body invites

## Applications for an Assistant

LECTURESHIP IN PHYSICS in the College of Technology.

Salary £350 per annum.

Conditions of appointment and form of application may be obtained from the REGISTRAR, College of Technology, Manchester. The last day for the receipt of applications is Monday, 15th March, 1920.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment. D 837

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

DEPARTMENT OF METALLURGY.

The Governors invite

## Applications for the Pro-

FESSORSHIP OF METALLURGY, vacant by the transfer of Dr. C. H. Desch to the University of Sheffield.

Applications must be sent not later than March 20th, to the DIRECTOR, The Royal Technical College, Glasgow, to whom inquiries should be addressed. D 858

CORPORATION OF CALCUTTA.

APPOINTMENT OF LIGHTING SUPERINTENDENT.

## Applications are Invited for

the POST of LIGHTING SUPERINTENDENT, Calcutta. The salary of the appointment, inclusive of all allowances, is Rs. 750 rising to Rs. 1000 per month by biennial increments of Rs. 50. The Corporation provide a motor car for the use of the Lighting Superintendent and his staff, free of charge, for inspection work.

The appointment is subject to the Provident Fund, leave and other service rules of the Corporation, and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 6¼ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation, and the fund accumulates at compound interest. The select candidate will be required to devote his whole time to the duties of his office, and will not be allowed to take up any outside work. He must reside in Calcutta. He will be liable to removal during the term of his office for misconduct, or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment. The Corporation will pay his passage (first class) from London to Calcutta, but he must refund the amount so paid if he gives notice within two years from the date of taking up his appointment. He will be required to take up his appointment about the 1st August, 1920, and will receive half pay for the period occupied by his journey.

(b) There are about 12,000 incandescent gas lights in the city, besides a number of electric and oil lights. Gas and electricity are supplied by public companies. The Lighting Department of the Corporation are responsible for the maintenance of the public street lamps, and also of about 2300 lights and 800 electric fans in Municipal Buildings. Candidates must have experience of the Management and control of the Lighting Department of a large town. They must have thorough and up-to-date knowledge of mantles, burners, etc., photometric work, testing pressure, and determining the discharging capacity of burner nipples. They must also have a general knowledge of electrical work.

(c) Candidates should state their age and experience.

(d) Applications will be received by the Secretary to the Corporation of Calcutta Central Municipal Office, Calcutta, up to 1st May, 1920.

J. C. MUKERJEA,
Secretary to the Corporation.
28th January, 1920. D 877

GUILDFORD EDUCATION COMMITTEE.
(Acting for the Surrey County Council.)

GUILDFORD TECHNICAL INSTITUTE AND JUNIOR TECHNICAL SCHOOL.

## Assistant Master, with Works

experience, REQUIRED to Teach Workshop Practice and Metal Work in the Junior Day School. Commencing salary £185 to £240, according to qualifications and experience, with £10 increments to £300. The Master should also be qualified to instruct Evening Students in General Engineering Workshop Practice, at extra pay according to scale. Applications, stating age, qualifications with works and teaching experience, accompanied by recent testimonials, should be sent to the undersigned as soon as possible.

F. S. TOSSWILL,
Technical Institute, Secretary.
Guildford.
20th February, 1920. D 852

CITY AND COUNTY BOROUGH OF BELFAST.

The TECHNICAL INSTRUCTION COMMITTEE invite

## Applications for the Position

of INSTRUCTOR in MOTOR ENGINEERING and ENGINEERING WORKSHOP PRACTICE at the Municipal Technical Institute, Belfast.

Salary, £280 per annum, including Bonus.

Particulars of the Duties and Conditions of Appointment, together with Form of Application, may be obtained from the undersigned, with whom applications on the special Form provided for the purpose, must be lodged not later than Monday, 8th March, 1920.

Applications should be accompanied by copies of three recent Testimonials (original Testimonials must not be sent).

Canvassing is strictly forbidden and will disqualify.

RUPERT STANLEY,
Municipal Technical Institute, Principal.
Belfast. D 867

## Required Inspector of Works

for wharves in course of construction in Federated Malay States. Must be thoroughly experienced in reinforced concrete work. Salary £30 per month and a war bonus of 30 per cent. of salary, free quarters, half pay on voyages and free passages.—Applications giving full particulars of experience and age should be sent to X.Y.Z., care of Brown's Advertising Agency, Tothill Street, Westminster. D 911

## Machine Tools.—Firm with

branches in England and Abroad have VACANCY for GENTLEMAN'S SON, preferably fresh from Public School or University, to train under their London Manager in Engineering and Salesmanship. Small salary paid while earning. Good prospects and permanent position.—Address, D 741, Offices of Engineering

## Large Engineering Firm in

North-Eastern County REQUIRE at once an ASSISTANT to CONTROLLER of STORES. Applicants must be well educated and experienced in Stores Department Accountancy, and up-to-date method of costing manufactures.—Apply, giving full particulars of experience, age and salary required, D 824, Offices of Engineering.

## Junior Chemists Wanted for

shift work for Electric Steel Furnace Plant.—Apply, stating age, and salary required, THE NEWCASTLE ALLOY COMPANY, Limited, Rowlands Gill, Near Newcastle-on-Tyne. D 823

## Wanted, Experienced Esti-

MATOR, with ability to specialise on Woodwork.—Apply stating experience and wages required, VICKERS, Limited, Dartford. D 845

## Estimator Required. Must be

thoroughly acquainted with calculations of material, able to fix labour prices from drawings, also modern machine and assembly shop methods. Preference given to one with knowledge of telephone and small electrical apparati. Permanent progressive position for really capable man. Write, stating fullest details, age and salary required, BOX 781, Sell's Advertising Offices, Fleet Street, E.C. 4. D 835

## Surveyors.—Wanted, for Large

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# LITERATURE.

*Irrigation Engineering.* By ARTHUR POWELL DAVIS, D.Sc., Director and Chief Engineer, United States Reclamation Service, and HERBERT M. WILSON, C.E., former Chief Engineer and Irrigation Engineer, United States Geological Survey. Seventh edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 21*s.* net.]

MR. WILSON'S work on Irrigation, of which the original edition dates back to a time prior to the establishment of the United States Reclamation Service, and has since seen six editions, may claim the respect due to a classic. Mr. Wilson drew his inspiration from the great canal builders and operators in India and Egypt, of whose labours he partook and in whose triumphs he shared. Now another hand, one in close touch with recent applications and developments, takes up the tale the master told so well, and adds another chapter to the history of engineering science, describing the methods by which a wider distribution of water over the infertile and parched lands of the Western States has increased agricultural production and improved the conditions of life.

Such a magnificent structure as the Roosevelt Dam, that ensures a reservoir capacity of 400,000,000,000 gallons of water, or the rubble concrete arch of the Arrowrock Dam that rises 350 ft. from its base, and measures more than 1,000 ft. along the crest, are by their appeal to the imagination apt to create erroneous notions of the real work of the irrigation engineer, what it involves in construction and entails in maintenance. The modest but essential work of preparation that makes these spectacular displays possible is overshadowed on their completion, and we forget the many problems of physics and topography, of agriculture and tillage, of supply and drainage and even of law and finance, that have had to be settled by scrupulous attention to details. None of these points is overlooked in this treatise, and many others are introduced, so that the scope is wide, embracing the whole mechanism of an irrigation project, and is not limited to the construction of the engineering devices whose purpose is the collection, distribution and removal of water. The ground covered is so extensive that an adequate notice within a reasonable space is not possible; the most that can be attempted is a general sketch of the course followed.

As a matter of history the Reclamation Law, whose adoption has been the means of converting barren and desert lands into delightful homesteads, did not come into force till 1902, though irrigation, partial and scattered, was of course practised long before. But at that date the need of systematic effort became manifest. The easier developed stations had been appropriated and were worked unmethodically, and often in a manner that, by preventing the profitable employment of corporate capital on larger schemes, checked irrigation enterprise. The remedy was found in the passage of the Reclamation Act, whose main feature was the creation of a fund, raised from the disposal of public lands in the arid States, which could be employed in the construction of irrigation systems. The Act also provided that the beneficaries should refund the cost of construction by the payment of small instalments spread over ten or twenty years, the money collected going back into the Reclamation Fund for use on fresh projects. From the first the scheme has been a great success. Before the war, the various projects supplied water to more than 1,500,000 acres and the works in progress, when finished, will approximately double this quantity.

Though the amount of rainfall, its measurement, distribution and available run off are of prime importance in irrigation schemes, and are naturally adequately considered by the authors, the collected information may be passed over in this summary, though successful agriculture depends greatly on the deductions drawn from meteorology and geology. Similarly we can no more than mention those other sources of water, as springs and artesian wells, which of necessity have been used to assist in the production of crops where natural precipitation fails, and which in their aggregate are by no means negligible. In India, for example, some 3,000,000 acres are irrigated from wells, one well often supplies 4 acres. But in that country each unit is small, is constructed on lines sanctioned by antiquity and is operated by immemorial usage. Tunnelling, the substitution of horizontal for vertical wells, is a more modern outcome, rendered possible by improved boring tools and more powerful machinery, but the source of the water is the same as of old. Both the normal well and the tunnel utilise that which having fallen on the surface has seeped into the soil and is collected in the well or tunnel. One advantage of the tunnel is conspicuous: The water it holds and conveys has not to be pumped to bring it to the level of the surface, but guided by gravity it finds its way to the lands to which it is to be applied. The bountiful subsources tapped by the Spring Valley Water Company for supplying San Francisco show that these tunnels may be destined to play a very important part in the carriage of water, and that their field of usefulness is by no means fully explored.

To dispense with pumping is to come within measurable distance of modern irrigation schemes. By lifting water a few feet, the pump has done such valuable work in irrigating lands higher than the water surface, and is seen supplying cities with a domestic service that requires a large supply, that the impossibility of using pumps for large-scale irrigation works is not easily realised. The value of irrigation water, however, is limited by the value of the crops raised, of which it is only one element of cost, and this low unit value of irrigation water defines the amount that may be prudently expended on plant and operation costs. The agriculturist in the arid region has to compete with the farmer in the humid, whose water costs him nothing. It is true, that the owner of the irrigated crop has his water at the times and in the quantity needed, or can withhold it at will, but for these advantages he can afford to pay only a small price. Pumping, as generally understood, is only feasible for irrigation purposes where the water supply is ample, the lift moderate, the power cheap and the crop valuable. In the Hawaiian Islands, it is said that water is lifted 500 ft. by steam power to irrigate the sugar cane. The crop must be very valuable to justify such a lift, but labour may be very cheap. These remarks apply mainly to wind mills, water wheels, centrifugal pumps and, in a less degree, to the Humphrey explosion pump. But in certain cases of which the Minidoka Dam furnishes an example, it is possible to develop power under such head as the dam affords, about 46 ft., to lift irrigation water to additional land not accessible by gravity flow, and the excess energy is sold for the benefit of the project. The power is produced at a cost averaging slightly over 1 mill per kilowatt-hour, and this includes all operating expenses and plant depreciation. At Minidoka 120,000 acres are under irrigation, of which 35,000 acres are supplied by pumping. In this case it will be noticed that pumping would not be possible unless the dam existed; it is the scheme itself that has made the pumping feasible.

Pumping exhausts the devices of old time irrigation, and to embark on a huge modern project in which gravity is the main agent of distribution involves machinery planned on other lines. The first essential is to select land of such a slope, that the water may be induced to run over it from canals and ditches, arranged short distances apart. A desirable slope is between 10 ft. to 30 ft. per mile in the direction of greatest slope. Water will not travel freely over the farms at less than the lower limit, and if the maximum is exceeded special devices have to be adopted to prevent the water acquiring a destructive velocity. Whether a greater or less slope can be tolerated is a question of expense to be decided by the value of the land or the character of the crop. The fertility of the soil should be high, and as a rule, aridity of soil is favourable to fertility, because the soluble salts that are necessary for plant food are not leached out by excessive moisture, though on the other hand, it may not infrequently happen that some salts as carbonate of sodium ($Na_2CO_3$) may be so abundant as to be injurious to vegetation. This salt is the well-known and shunned "Black Alkali," dreaded whether originally on the ground or encouraged by bad farming. The only satisfactory remedy for this scourge is deep drainage, accompanied by copious surface irrigation, operations that cost both time and money, and the application has the additional disadvantage of leaching out of the soil much of the plant food that would be valuable to vegetation. Clearing the soil of indigenous growth, levelling the surface, providing ditches to take the water along the upper edge of each field, are operations fully described in the book under notice, for if they lie apparently outside the scope of irrigation, the ultimate success of the scheme depends upon the thoroughness with which they are carried out. Land that appears smooth to the eye will be found under adequate test to have undulations, that cause the water to over-irrigate the depressions while the elevated spots remain unwatered.

Where the land is properly prepared the water is distributed over the surface by means of open canals and laterals, though in a few cases where water has considerable value, cement pipes are used to avoid evaporation, or seepage, and in orchards, subterranean pipes are sometimes employed to carry water to each tree. Several methods are described for distributing the water over the land, for evidently it is not an easy task to supply to the surface of a whole farm a sufficient and uniform quantity of water since the whole crop needs simultaneous treatment. The plan which the authors recommend is that known as "flooding between borders," or dikes, a plan which secures good results in an expeditious manner, for these "borders" being raised a few inches above the surface, it is possible, on ground properly levelled, to make the water flow between these "borders" as on a broad shallow canal from the upper to the lower end of the strip. Experience is required to decide when sufficient water has started down the strip to accomplish its mission, without waste or fear of over-irrigation, and here is approached one of the weaknesses of the American system. The physical manipulation and operation of an extensive reservoir and canal system is an intricate problem, that calls for both skill and knowledge on the part of those who are dependent upon that system, and unfortunately the Reclamation Act imposes no restrictions on intending farmers. Any citizen, without qualification or previous experience, can take up a lot of 160 acres and by his ignorance or carelessness injure fatally what science has constructed with infinite pains. The dweller in a dry land, unused to irrigation, is disposed to believe that water is so good a thing that he cannot have too much, and in his resolve that his crops shall not suffer, applies water so lavishly that the ground water is brought to an elevation where it can be reached by the roots of the growing crops. Such practice is wasteful of water and ruinous to the land: It leaches out the plant food, it waterlogs large areas of land, and brings to the surface whatever alkali the soil contains. India and Egypt have suffered from this mistaken policy, and in Southern California, to quote a specific instance, this pernicious practice was deliberately followed for years under the belief that bringing up the ground water by copious irrigation was beneficial to the crops. The result has been the ruin of thousands of acres of fertile soil by waterlogging and alkali, has wrecked many flourishing towns, and depopulated rural districts like a pestilence. It is difficult to persuade the farming community of the advisability of using water economically, when it stands so close to the edge of the farm, that it is beneficial to apply less than the quantity giving the maximum yield, and generally it pays better to stop far short of the maximum. The "duty of water" or the area which can be served by a unit quantity of water, varies very greatly in different projects, some requiring no more than 2 ft. on the land during the season, while others demand as much as 12 ft.

Wherever the land is traversed by numerous canals, unlined with concrete or other form of protection, there will be much seepage, and the quantity may be so large as nearly to destroy the value of the undertaking. The average losses under ordinary conditions should not exceed 1·5 ft. per day, and under favourable circumstances will fall below half a foot. The excess will cause a

rise in the height of the free water, in extreme cases rendering the land unfit for cultivation, and increasing the number of derelict farms. A constant watch has to be kept on the height of the ground water, and this is best effected by means of wells sunk along the canal track. When a rise in the water plane is noted, steps must be taken to prevent the water coming too near the surface, by reducing the losses in the canals, supplying less water to the land in irrigation, and constructing drains for the removal of excess water. The types of drain used include both covered tile lines and open ditches. The latter are the more common as they are found to act effectively, while the efficiency of the tile lines may be seriously impaired by accumulation of sand, or by moving out of line. The subject is a very large one, the removal of excess water is quite as important as the conveyance of water to the land, and the authors' description is very detailed.

Technical details necessarily increase as the subject passes from the general principles involved in irrigation to the description of canal structures, many of which have been designed to meet particular requirements. Under this head must be placed all the mechanical devices for the collection and conveyance of water, apart from the earthen waterway itself. Spillways and headgates, drops and checks to diminish erosion, form one distinct class necessary for the control of canal water, while flumes, inverted siphons, and culverts figure among the special devices adopted to avoid difficulties and obstructions, that would interfere with the performance or endanger the safety of the canal. Tunnels, regarded as a means of conveyance may be placed in the latter class as they offer the alternative of perforation when flumes are inconvenient. The tunnel is expensive to construct, but cheaper to maintain, and flumes or canals carried round the side of a hill are very hazardous. The most daring instance of American canal tunnelling is that of the Gunnison Tunnel, constructed to bring a river to the valley of the Uncompahgre to supplement the meagre flow of that river. This tunnel is 30,000 ft. long, cost over 3,000,000 dols., or 101 dols. per foot. In the hazards of construction and amount of work achieved, it rivals the great railway tunnels through the Alps.

The storage reservoir is another expensive item in any irrigation project, and the selection of a reservoir site is a matter for a practised eye and trained judgment. It may be easy to decide the conditions that constitute an eligible site, but nature seldom offers the combination that will satisfy the geological, topographical, financial and engineering requirements. Leakage from reservoirs is perhaps the most frequent source of failure and annoyance. The Deer Flat Reservoir offers a good example of the loss that may come after all precautions have been taken, of the confidence of engineers in the efficiency of their remedies, and of the final triumph of success. When full this reservoir covers 9,800 acres, and contains 180,000 acre-ft. In 1909, about one third of this quantity was run into it, nearly all of which was lost by seepage, not more than 17,000 ft. being in the reservoir at one time. Many believed the reservoir doomed, but subsequent service showed rapid improvement, and in 1917, the seepage losses were equivalent to less than 0·2 in. per day. This improvement was due to filling up all the subsoil with water, which could not rapidly escape, and not to any abnormal tightness of the soil.

The losses and inconvenience that arise from abundance of water may exceed those from leakage and deficiency. No one can foresee the magnitude or the manner of occurrence of the largest flood against which it is necessary to take precautions. Local signs and short records, though invaluable in determining minimum flow, can be misleading in the case of floods. It would, indeed, be marvellous if an available record for ten or twenty years contained the largest flood of all the centuries. The floods of 1913 in the Miami valley carried away structures that had stood unharmed for half a century. On the Sacramento, the records showed that the greatest flood to be expected was 80,000 cub. ft. per second. Yet since that estimate was made, a flood of 200,000 cub. ft. per second has been recorded. Such examples demonstrate the risks that have to be taken on irrigation projects, and the courage of the engineers is equal to the responsibility. The loss of the original capital, though large, is a small loss in face of the thousands of homes that would be ruined, and the consequent disorganisation of a province, if the scheme fails of its purpose through any cause. The erosion, with the amount of sediment brought down, is an additional menace, that is always overhanging the design, and the extent of this impending evil, like the other factors, can be judged only very imperfectly. In many cases a reservoir would be completely filled with sediment in the course of a few years unless adequate preventive measures were adopted.

Continued watchfulness is practised in other directions, and though the conditions of safety may be enunciated with confidence, their realisation is difficult. Storage dams in particular notwithstanding the care bestowed on construction and the experience gained in designing, will occasionally cause serious accidents. Clay is a very troublesome material to control. It will hold on to the contained water with great tenacity, and when saturated exerts a hydrostatic pressure on the retaining dykes which may exceed their power of resistance. The disasters at Necaza and on the Calaveras Dam, where the clay flowed out like a torrent into the respective reservoirs, illustrate the dangers of using clay in construction. Other accidents have occurred from the overtopping of the dam by a great flood wave. In such cases the spillway is generally found to be of insufficient capacity, but such calamities demonstrate some of the unknown factors against which the engineer has to struggle, and justify the provision of a liberal margin of safety. Accumulated experience from the past is the best guide to future construction: The history of progress is a very material aid to successful endeavour, and in this volume are collected all the material facts which can assist the irrigating engineer and on which he can rely for sure guidance. The arrangement is clear and well designed, the illustrations are informing and lavishly provided, and to the practical man such an encyclopedic work will prove invaluable.

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*The Hydrogenation of Oils. Catalysers and Catalysis and the Generation of Hydrogen and Oxygen.* By Carleton Ellis. Second edition. London: Constable and Co. [Price 36*s.* net.]

While we agree with Mr. Carleton Ellis that the surprising strides of the oil-hardening industry, as well as the improvements of hydrogenation processes called for the publication of a thoroughly revised and enlarged edition of his book, which stands high among technical treatises on this subject, we also think that he might, on this occasion, have limited himself to the main subject, the hydrogenation of oils. There is no dearth of recent books on the generation of hydrogen and oxygen, and most of us have no preference for bulky and heavy volumes, where a handy volume might contain all the information required. The first edition of the book, which appeared in 1914, was an octavo publication of 338 pages; the second edition of 1919 exceeds, with its 767 pages and 240 illustrations, double that size. Most of the additions are welcome novelties, and in the copious references—very largely to patent literature—the war years are very prominent. That feature will be much appreciated by the many chemists and engineers who, whether at the front or in their country during the war, were in that long period practically cut off from their own line of work. The novelties are by no means restricted to the first 440 pages on methods of hydrogenation, catalysis and hydrogenation products, among which edible foods have become more important almost than soaps, and on hydrogenation practice. But with page 441 we pass to the generation of hydrogen and oxygen, and that whole section, though likewise well stocked with innovations, might have been omitted apart from the chapter on Precaution in Handling Hydrogen, Safety Devices and Purification of the Gases. There is further an appendix of a hundred pages. The first appendix, A, is taken over from the first edition; it reproduces the judgment of the British Court in the patent litigation of 1913, between Messrs. Crossfield and Sons and the Techno-Chemical Laboratories, which brought out a great deal of technically and historically important matter. But in Appendix B, 79 pages are given to an account (not a judgment) of another litigation decided before the United States District Court of Justice at New York, in October, 1917. The master patent contested in this latter case concerned edible foods, again a very important matter; yet we should have thought that "lack of space which forbids the publication of the record in full" might have prevented the author from wearying the reader with pages of irrelevant court proceedings.

One of the excellent features of the volume, itself unusually complete, is the very complete index of 56 pages, appended, Mr. Ellis says, owing to certain difficulties of classification. The difficulties do not appear to have troubled him much in other respects. For the new edition is simply enlarged. The book remains largely what it was in its lack of systematic arrangement. In many chapters the different inventions and novel suggestions are simply strung together. Chapters are devoted to methods of hydrogenation, to base-metal and rare-metal catalysers, to the occlusion of hydrogen, to properties and uses of hydrogenated products, to the hydrogenation of petroleum, &c. There is a special chapter of 5 pages on hydrogenation practice. But details—so far as available at all—about a particular process may be found in any chapter, and if it were not for the very carefully-compiled index, one might frequently despair of discovering the desired information. We do not underrate the difficulties of systematic classification in this field, and the chief thing is that we have the fullest material, including the most recent, brought together by a competent man. The subject is, of course, the author's own, and the name of Mr. Carleton Ellis, who lives in Montclair, New Jersey, U.S., occurs very frequently in the patents quoted.

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## BOOKS RECEIVED.

*Robinson's Manual of Radio Telegraphy and Telephony*, 1919. By Captain S. S. Robinson, United States Navy. Fifth revised edition. Annapolis, Md.: The United States Naval Institute. [Price 1 dol. 50 cents.]

*The British Journal Photographic Almanac and Photographers' Daily Companion*, 1920. Edited by George E. Brown, F.I.C. London: Henry Greenwood and Co., Limited. [Price 1*s.* 6*d.* net.]

*The British Dominions Year Book*, 1920. Edited by Edward Salmon, F.R.C.I., and James Worsfold, F.C.I.S. London: Eagle, Star and British Dominions Insurance Company, Limited.

*Mechanical World Year Book*, 1920. Manchester and London: Emmott and Co., Limited. [Price 2*s.* net.]

*The Management Problem.* By Edward T. Elbourne. London: The Library Press, Limited, 26, Portugal-street, W.C. 2. [Price 4*s.* 6*d.* net.]

*The "Practical Engineer" Mechanical Pocket Book and Diary for* 1920. London: Technical Publishing Company, Limited. [Price 1*s.* 6*d.* net.]

*The Business Man's Guide to the Peace Treaty.* By H. Fletcher Moulton. London: George Allen and Unwin, Limited. [Price 3*s.* 6*d.* net.]

*Land Drainage from Field to Sea.* By C. H. J. Clayton. London: *Country Life* Offices, 20, Tavistock-street. [Price 6*s.* net.]

*An Episode of the Great War. The Limburg Manœuvre of August*, 1914. By Captain "Candid," of the Nederlands Army. Utrecht: A. W. Bruna and Son Publishing Company.

*Private Companies. Their Utility and the Exemptions they Enjoy.* By Herbert W. Jordan. Ninth edition. London: Jordan and Sons, Limited. [Price 1*s.* net.]

*Transactions of the Institution of Naval Architects.* Vol. LXI. 1919. Edited by R. W. Dana, O.B.E., M.A. London: Henry Sotheran and Co., 43, Piccadilly.

*United States Department of the Interior, Bureau of Mines.* Technical Papers: No. 96, *Fume and Other Losses in Condensing Quicksilver from Furnace Gases.* By L. H. Duschak and C. N. Schuette; No. 203, *Labour-saving at Limestone Quarries*, by Oliver Bowles; No. 215, *Accidents at Metallurgical Works in the United States during the Calendar Year* 1917, compiled by Albert H. Fay: No. 217, *Saving Coal in Steam Power Plants.* Bulletin No. 174. *Abstracts of Current Decisions on Mines and Mining. Reported from May to September*, 1918. By J. W. Thompson. Washington: Government Printing Office.

*Memoirs of the Geological Survey. Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for* 1918. London: E. Stanford, Limited, 12, L ng Acre. [Price 2*s.* 6*d.* net.]

*Reminders for Company Secretaries.* By Herbert W. Jordan. Fourth edition. London: Jordan and Sons, Limited, 116, Chancery-lane. [Price 9*d.* net.]

*Transactions of the Engineering Institute of Canada.* Vol. XXXII., 1919. Part I. *The Quebec Bridge.* Part A. *Plates to accompany Text of Part I.* Montreal: Published by the Institute.

*Hot Bulb Oil Engines and Suitable Vessels.* By Walter Pollock, M.I.N.A. London: Constable and Co., Limited. [Price 42*s.* net.]

*Motor Repair Work for the Amateur Mechanic and Owner-Driver.* Third edition. London: Temple Press, Limited. [Price 1*s.* 9*d.* net.]

## LARGE STEAM TURBINES.

THE first large turbo-generator of modern type set to work in the United States was the 20,000-kw. to 25,000-kw. unit supplied to Chicago by Messrs. C. A. Parsons and Co. It is, we believe, generally admitted that the tests of this machine revealed for the first time to American power-plant operators, that they had been hitherto content to accept from builders, turbines far less efficient than they had a right to expect, and the general result was an improvement of fully 10 per cent. in the steam rates previously demanded. Though the plant above referred to, may fairly be considered as the pioneer of the modern large-capacity units, the further development of the type has unfortunately to be sought in the main elsewhere than in the country where it originated, since owing to the folly of Parliament in discouraging private enterprise we have been committed in this country to a system of electrical supply from innumerable small stations, often badly situated both as to supplies of fuel and of condensing water. The modern power station is founded in the main on the work of three British subjects, viz., Sir Charles A. Parsons, Mr. C. E. L. Brown, and Mr. Ferranti, but the wealth which would have accrued to this country had the work of these three men of genius been allowed free development here, has for the most part been secured by other communities. Thus, although no successors to the pioneering plant at Chicago are yet operating in this country, a considerable number of very large units, both of the impulse and the reaction type have been set to work in the States. The new departure has, it is true, not in all cases been a success, particularly in the case of the impulse turbines. Thus, only a year ago, the 35,000-kw. turbo-generator belonging to the Boston Elevated Railway Company was completely wrecked. Fortunately for the prospects of this type the matter was much less serious than reported in the American technical press at the time, where it was stated that the complete investigation which followed the disaster had shown that the unhappy event was in no way attributable to errors of design, bad workmanship or to the use of faulty materials. Had this statement been correct it would have been necessary forthwith to abandon the attempt to operate impulse units of such large dimensions; but, as a matter of fact, there were serious errors in the design, since the turbine wheels though strong enough, were not stiff enough, and in this lack of rigidity is to be found the explanation not only of the Boston wreck, but of other failures elsewhere.

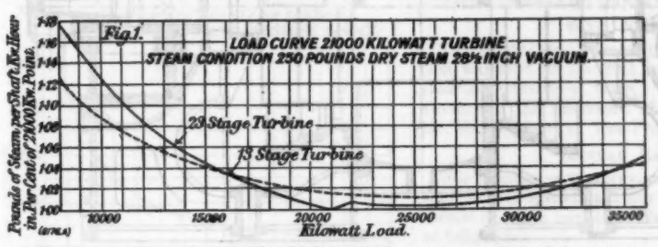
A very interesting and important paper describing the characteristics of these large turbines as now constructed, and the modifications in design which have been introduced as a consequence of such experiences, as those at Boston, was read before the American Institute of Electrical Engineers last autumn by Mr. Eskel Berg. In this paper the author gives the limits of size now considered practicable in the case of single-shaft Curtis turbines. With saturated steam supplied at 250 lb. gauge pressure, and exhausted at a 28½-in. vacuum, Mr. Berg states that the limiting size of turbine giving a maximum efficiency under these conditions is 21,000 kw. when the speed of revolution is fixed at 1,800 r.p.m. (Fig. 1). Such a turbine would have 23 pressure stages, the mean diameter of the wheels being 35 in. at the high-pressure end and 88 in. at the low-pressure end. He admits a bucket length at the last wheel equal to one-quarter of the mean diameter, the inlet and discharge angles being 60 deg. and 40 deg. respectively. By by-passing the first 11 stages the load taken by such a turbine could be increased to 36,000 kw., but the steam rate would simultaneously be increased by 5 per cent. The effect of increases of vacuum on the steam rate, at loads of 21,000 kw. and 36,000 kw. respectively is shown in Fig. 2, reproduced from Mr. Berg's paper. At the lower load the improvement effected by raising the vacuum from 28½ in. to 29 in. is 2½ per cent., whilst at the maximum output of 36,000 kw. it is only 0·55 per cent., since in this case the loss of energy by "carry-over" to exhaust becomes very high. By replacing 13 of the high-pressure stages of this turbine, by a two-row velocity compounded wheel (presumably of 88 in. instead of 35 in. mean diameter) the turbine would be greatly shortened, but the maximum efficiency would, according to Mr. Berg, be reduced by about 1½ per cent. At loads below 16,000 kw., however the 13-stage turbine thus constructed would have a better steam rate than the 23-stage turbine, as with the velocity compounded wheel the reduction in output is effected by cutting out nozzles instead of by wiredrawing the steam.

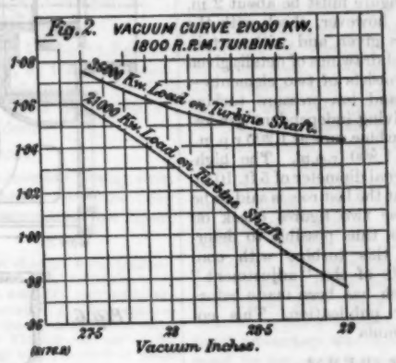
At maximum efficiency, the energy accounted for by the last wheel of such a turbine as the foregoing is 11½ per cent. of the total adiabatic heat-drop, and the wheel efficiency is said to be 65½ per cent., falling to 54·2 per cent. if the load goes up to 36,000 kw., in which case 20·9 per cent. of the total adiabatic heat drop is accounted for in the last wheel.

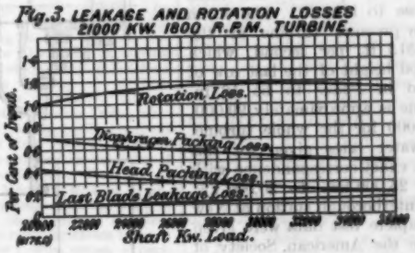
Mr. Berg gave the diagram reproduced in Fig. 3, which shows the amount of the various "parasitic" losses in a turbine of this type. Some similar figures independently calculated are given below, and may be of interest:—

The design of the low-pressure wheel is represented in Fig. 4; in it are embodied the changes considered desirable as the result of the Boston and other accidents. Mr. Berg states that there has, in fact, been serious trouble through cracks developing in forged wheels when in service. These cracks have formed either at the holes provided for equalising the pressures on both sides of the wheels or made for the attachment of balance weights. Calculations made subsequently to the failures showed that the computed stresses were less than in many wheels made of weaker material, which had given no trouble, and the failure has been traced to a lack of lateral stiffness in the wheels. The impulse turbine designer has quite naturally aimed at making the discs used as thin as possible, so as to shorten his shaft, thus giving a more compact and lighter machine, with a high critical speed. In doing so he overlooked the possibility that very thin wheels might lack stiffness and respond to any vibration which chanced to synchronise with their own natural periodicity. Failures arising from such synchronism were referred to in our issue of February 16, 1917, page 158, and in the discussion on Mr. Berg's paper, Mr. Emmet stated that the phenomenon was well shown with thin india-rubber discs rotated at a high speed. In such conditions the edge of the disc, instead of remaining flat, takes a snake-like form. If this kind of thing happens with a turbine wheel and the clearances are small, the periphery may come into contact with the diaphragm and get red hot. In some cases the vibration causes the blades to break, and in others, as mentioned by Mr. Berg, the wheel fractures owing to the alternating stresses set up at points where the stress under normal conditions is already high. If holes are drilled through the discs of an impulse turbine, as is usually done, the maximum stress at the hole is greatly increased.

Thus, assume that with a solid wheel the tangential stress at any point is $t$ and the radial stress is $r$, then, if a hole is drilled through the disc at this point, at the sides of the hole the stress will rise to $3t - r$. With steady stresses this gives no trouble, as the metal, if over-strained, simply stretches a little and thus relieves itself, and no harm is done. Experience, indeed, has shown that there is no very direct connection between computed stresses and factors of safety when the stresses are steady, and the stresses due to the centrifugal forces acting on a rotating disc may be taken as typical steady stresses. There is, however, no question but that with alternating stresses the computed stress is really a measure of the safety of a structure, and accordingly when turbine discs are thin enough to vibrate there is a danger of cracks, which, as Mr. Berg states, start at places where, owing either to the presence of holes or to defective material, the metal is already highly stressed. The remedy is to stiffen the wheels, and to locate the balancing holes in places where a surplus of metal can be readily provided. It is on these lines that the wheel represented in Fig. 4 has been designed. The material used is a 4 per cent. nickel steel



| Rated Output, Kw. | R.P.M. | Loss by Windage and Disc Friction. | Loss at Steam Glands. | Loss at Bearings, Thrust Blocks and Water Glands. | Remarks. |
|---|---|---|---|---|---|
| | | per cent. | per cent. | per cent. | |
| 25,000 | 1,500 | 2·26 | — | 0·61 | Tandem impulse turbine. One velocity wheel at high-pressure end. |
| 5,000 | 750 | 2·9 | 0·5 | 1·32 | Pure impulse turbine. Water glands. |
| 15,000 | 1,000 | 1·7 | — | 0·50 | Pure impulse turbine. |
| 8,000 | 1,500 | 3·1 | 0·1 | 0·47 | Impulse turbine. One velocity wheel. |
| 3,000 | 1,400 | 4·1 | — | 0·84 | Pure impulse turbine. |
| 3,000 | 1,500 | 3·1 | — | 0·81 | Pure impulse turbine. |

forging, heat-treated. The metal has an elastic limit of at least 55,000 lb. per square inch, and the maximum working stresses are marked on the diagram.

In another paper read at the same meeting, Mr. J. P. Johnson gave some particulars as to the corresponding large reaction turbines which have recently been constructed in the States by the Westinghouse Company. For the most part, however, the Westinghouse Company have favoured, for large outputs, a double shaft machine, the general arrangement of which is well represented in Figs. 5 and 6, which are reproduced from *Power* of August 27, 1918. The machine represented was built for the Narragansett Electric Lighting Company, and was designed to develop 30,000 kw. at maximum economy, at which the steam rate is 11·8 lb. per kilowatt-hour, with a supply at 200 lb. gauge, 100 deg. F. superheat and a vacuum of 29 in. By means of a by-pass the output can be increased to 45,000 kw., at which the steam rate is 12·02 lb. per kilowatt-hour. Whilst the main dimensions of the turbine are correctly represented, the blade heights are obviously not drawn to scale, those at the high-pressure end being represented as 4 in. in length, whereas the true figure must be about 2 in. The principal dimensions, however, check with the maximum mean velocities given and with certain supplementary dimensioned drawings of details given in *Power*. The turbine consists of two elements—a high-pressure turbine and low-pressure turbine lying side by side, and driving independent generators. The high-pressure turbine runs at 1,200 r.p.m., and the low-pressure at 1,800 r.p.m. The high-pressure casing has an internal diameter of 5 ft. 10 in. and the mean blade speed at the last row is said to be 470 ft. per second. These two figures check on scaling the drawing. It is thus possible to determine the coefficient for this turbine with considerable accuracy, in spite of the "adjustment" of the blade heights, which has been made before passing the drawings for publication. This coefficient is given by the formula

$$K = n \cdot \left(\frac{d}{10}\right)^2 \left(\frac{\text{R-P.M.}}{100}\right)^2$$

where $n$ denotes the number of moving rows and $d$ the mean diameter of the row in inches. For the high-pressure turbine in question the value of K must be very close to 170,000. The mean blade speed of the low-pressure turbine at the last row is said to be 515 ft. per second, which checks with the measured height of the last row of blades, which is stated in *Power* to be 18 in. Hence K for this turbine is approximately 99,000, making a total of 269,000 for the whole turbine. The corrections and water rates given for this turbine in *Power* are in exact correspondence with those quoted for the 25,000-kw. to 30,000-kw. machine erected at the Interborough station at New York, of which very complete test data were given in a paper read before the American Society of Mechanical Engineers in 1916, and this latter has therefore no doubt practically the same co-efficient.

It may be of interest to give the "parasitic" losses in this turbine to compare with those given in Fig. 3 for a large impulse turbine, by Mr. Berg. The requisite dimensions were scaled from the engravings by a micrometer measuring device reading to $\frac{1}{100}$ in. The measurements, as repeated on different days, were identical within 2 mils:—

| | kw. |
|---|---|
| Losses in high-pressure bearings and thrust blocks ... ... ... | 55·3 |
| Losses in low-pressure bearings and thrust blocks ... ... ... | 36·2 |
| Losses in oil pumps and governor drive | 4·0 |
| ,, water glands ... ... ... | 80·0 |
| ,, dummies of high-pressure turbine equivalent to ... | 187·4 |
| Total ... ... | 342·9 |

There are some slight additional losses at the steam packings provided to back up the water glands, but although the design of these packings seems open to criticism, the total loss here cannot be large, as the pressures to which they are subjected are low. Neglecting this loss, and the losses by tip leakage for which data are not available, the total of these parasitic losses amounts to only 1·14 per cent. on an output of 30,000 kw.

In his paper, Mr. Johnson gives some interesting particulars as to the materials used for the large turbines built by the Westinghouse Company. The rotors and casings are mild steel castings having a tensile strength of 65,000 lb. to 70,000 lb. per square inch, and a true elastic limit of 22,000 lb. to 25,000 lb. per square inch, with an elongation of 15 per cent. to 18 per cent. (on 2 in. ?), and a reduction of area of 20 per cent. to 25 per cent. The steel, on analysis, shows about 0·25 per cent. carbon, 0·5 per cent. to 0·6 per cent. of manganese, 0·25 per cent. of

*Fig. 5.*

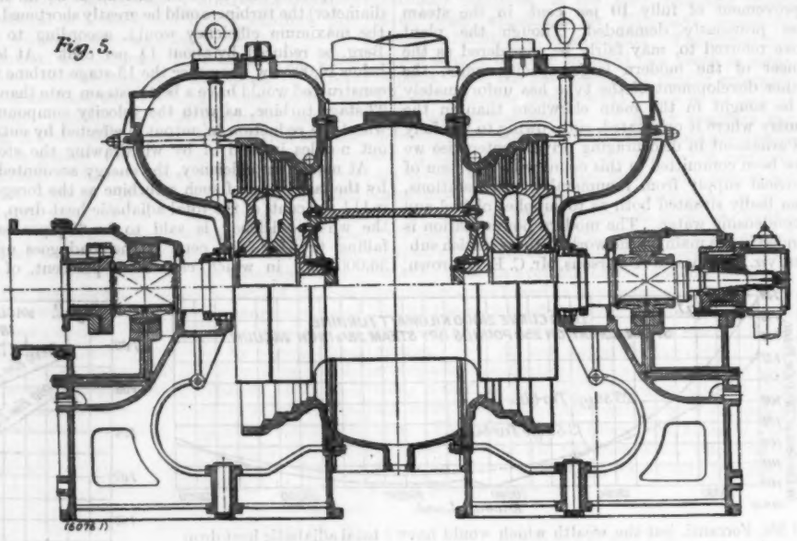


*Fig. 6.*

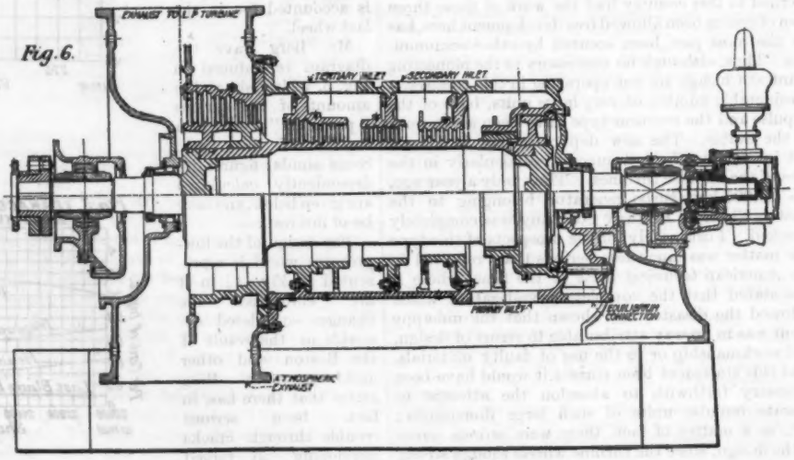
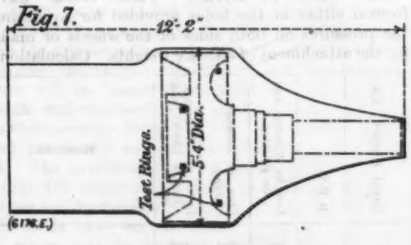



*Fig. 7.*




silicon, and not more than 0·025 per cent. of sulphur or phosphorus. Forgings made to the same specification have been used, but are, he states, difficult to obtain, excessively expensive, and not more uniform or reliable than castings. In order to ensure sound metal very large risers are used. The casting for a rotor end has the shape shown in Fig. 7—whilst the finished piece is represented by the dotted lines. The piece is cast with the axis vertical and the small end down, and is allowed to cool very slowly in sand. After removal, the enormous riser is cut off, and the remainder annealed at 1,650 deg. F. After rough machining, which brings the casting within $\frac{1}{4}$ in. of its finished dimensions, there is a second annealing at 1,100 deg. F. The material, after this, receives no further heat treatment. The stresses on the rotor being steady, a small factor of safety suffices, and parts are proportioned so that at 20 per cent. over speed the stress is 20,000 lb. per square inch.

For the low-pressure blading and for the velocity-compounded stage where such is adopted, a 5 per cent. nickel steel, made electrically, is employed At 20 per cent. over speed this is stressed to 25,000 lb. per square inch, the material having an ultimate strength of at least 65,000 lb., an elastic limit of at least 35,000 and an elongation on 2 in. of at least 30 per cent. The carbon content is kept below 0·08 per cent., whilst the silicon is less than 0·10 per cent. and the phosphorus less than 0·04 per cent. The manganese is kept between 0·4 per cent. and 0·5 per cent. After rolling into sections, the material is annealed at 1,425 deg. F. and cooled in the open air, receiving no further heat treatment. For the blading in which the maximum stress at 20 per cent. over speed does not exceed 15,000 lb. per square inch, a copper-tin-phosphorus alloy is used, having the following composition:—

| | |
|---|---|
| Copper ... ... ... | 97 to 98 per cent. |
| Tin ... ... ... | 2 ,, 3 ,, |
| Phosphorous ... | 0·03 to 0·07 ,, |

Mr. Johnson states that the blade angle for normal blades is 20 deg., and for the final low-pressure blades 35 deg. It may be pointed out that in general with Parsons blading the true angle of discharge is generally less than the nominal angle. Thus experiment has shown that when the nominal angle is 20 deg., the real angle of discharge is nearer 18 deg. than 19 deg., and there is apparently no correction necessary for the thickness of the blade

# LARGE STEAM TURBINES.

*Fig. 8.*

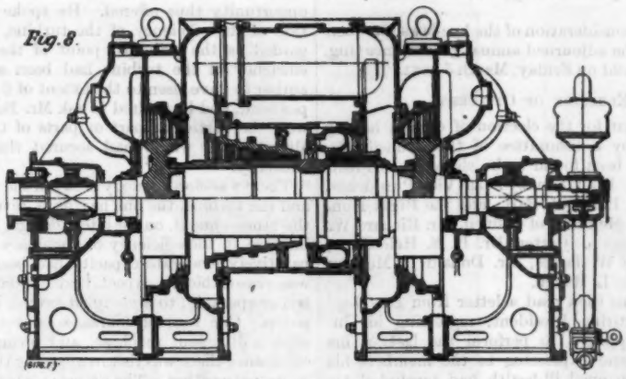
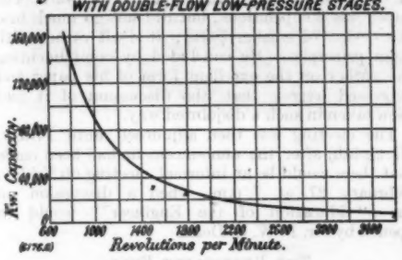


*Fig. 9.* LIMITS OF CAPACITY OF STEAM TURBINES WITH DOUBLE-FLOW LOW-PRESSURE STAGES.




the individual jets combining into a continuous stream, of which the flow makes an angle of about 18½ deg. with the plane of the guide blades. Recently some builders have been adopting reaction blading, shaped so as to render the jet parallel for a short distance near the point of discharge. It seems incredible that this is other than a retrograde move. The area swept over at maximum speed by the fluid is increased, and there would seem to be a probability of additional losses where the jets coalesce.

Whilst the Westinghouse Company have, in practice, favoured the division of these very large turbo-generators into independent high-pressure turbines, Mr. Johnson, in his paper, illustrates a single-shaft design, and discusses the limiting size at present considered possible. He does not, however, appear to be a strong advocate of the type; though prepared to build them should station operators demand them. The general arrangement proposed is illustrated in Fig. 8. The working conditions contemplated are a supply of steam at 250 lb. gauge pressure, 200 deg. superheat and a 29-in. vacuum. The first element of the turbine is, it will be seen, a velocity compounded impulse wheel which is followed by eight groups of reaction blades constituting the intermediate section of the turbine. The double-flow plan is adopted for the low-pressure section, the mean blade speed at the discharge end being 600 ft. per second. The curve reproduced in Fig. 9 shows what Mr. Johnson considers to be the limiting size of single-shaft machines of this type, now practicable. The machine is designed to give its maximum efficiency at 80 per cent. of its normal rating. Units actually constructed are represented by the crosses on the diagram.

In his paper, Mr. Johnson points out that the limit of size is not wholly an engineering question. Possibilities of transport have to be considered, and, as a matter of fact, the low-pressure rotors of the 30,000-kw. machine built for the Interborough Rapid Transit Company had to be shipped with the last stage blades removed.

Moreover, there are economic limits due to the fact that with present equipment, the shop costs tend to be higher than they would be in the case of smaller units. There are further objections from the operators' standpoint; the larger the turbine, the more serious the inconvenience caused by stopping it, for overhaul or repair.

## THE INSTITUTION OF MECHANICAL ENGINEERS.

THE annual general meeting of the above Institution was held on the 20th inst., at the Institution Building, Storey's Gate, Westminster. In the absence of the president, the chair was taken by Mr. Mark Robinson, Vice-President.

### ANNUAL REPORT.

The minutes of the previous meeting having been read, it was agreed that the annual report for 1919 should be taken as read. We summarise this report as follows:—

The seventy-third annual report showed a net increase in the roll during 1919 of 420. The total additions were 610, including 85 new members and 441 new associate members. The total deductions owing to deaths, registrations, &c., numbered 190. Of the members who have died during the year Mr. Albert Vickers was one of the oldest of the Institution, having been elected in 1865, while Mr. J. Hartley Wicksteed had served on the Council, and was President in 1903–4.

The Council placed on record their indebtedness to the Council of the Institution of Civil Engineers for allowing them the use of their hall during the war, and a grant of £50 had been made to the staff of that Institution in recognition of the assistance they rendered. The revenue for the year amounted to £22,683, and the expenditure to £24,842, including £7,000 invested fo the reserve. The total assets are £159,943; deducting debentures and other liabilities, and the total of the four reserve funds, there is a credit balance of £69,563. Grants were made as follows for research:—Alloys, £220; steam nozzles, £150; hardness tests, £150; cutting tools, £100. A grant of £20 from the Sir R. Hadfield Prize Fund to Mr. A. F. Shore, of New York, for a paper on "Hardness Determination," published in the journal of the Iron and Steel Institute, and one of £7 to Mr. J. Innes for his paper on "The Measurement of High-Degrees of Hardness." The following research work is in progress:—Alloys research at the National Physical Laboratory; steam nozzle research; hardness tests at the National Physical Laboratory; wire ropes, experimental work at Woolwich Polytechnic; cutting tools; piston rings.

### AWARDS.

The Starley premium for the best paper in 1917–1919 dealing with road locomotion was awarded to Mr. L. A. Legros for his paper "Traction on Bad Roads or Land." (Proceedings, 1918). The Thomas Hawksley gold medal for 1920 has been awarded to Mr. T. T. Heaton for his paper on "Electric Welding." (Proceedings, 1919.) The first award of the T. Bernard Hall prize has been made to Dr. W. H. Hatfield for his paper on "The Mechanical Properties of Steel, with some consideration of the question of brittleness" (Proceedings, 1919). At the Institution examinations of October a prize of £5 was awarded to Mr. S. J. Westcott.

### MEETINGS.

The monthly general meetings had been held as usual, and recently informal meetings had been instituted. The graduates meetings were resumed in October. The Institution took part in the Commemoration Meetings of the James Watt Centenary held in Birmingham in September.

On the movement for the adoption of the report, Mr. Percy L. Young referred to the Bill about to come before Parliament for the registration of engineers, and urged that the Institution of Mechanical Engineers should safeguard the interests of members of their branch of the profession. The chairman, in replying, remarked that a friendly discussion of the matter had taken place with the Institution of Civil Engineers, and a satisfactory understanding was hoped for. The Council of the Institution of Mechanical Engineers objected to the Bill, as it stood, and would oppose it if necessary. Dr. Hele-Shaw supported Mr. Robinson, observing that no member of the Institution calling himself a mechanical engineer need be apprehensive that the Institution would not safeguard the interests of mechanical engineers. It was hoped that in the result all classes of engineers would derive benefit, and particularly mechanical engineers.

### BYE-LAWS.

The chairman then presented the prizes which had been awarded to the several recipients named above. He next opened the question of the alteration of the bye-laws of the Institution, relating (1) to subscriptions, (2) to changes affecting age of entry into the different classes, and (3) conditions of election. With regard to subscriptions, it was proposed to raise the amount in the case of members from 3*l.* to 4*l.*, and in the case of associate members from 2*l.* 10*s.* to 3*l.* In regard to the associate grade, the council aimed at making it more important. Associates were elected as men who had attained eminence in connection with engineering, but were not engineers, and it was thought such men should be asked to pay the same subscription as full members. A change was also proposed in the entrance fees. Full members paid only 2*l.*; it was proposed that in future full members should pay 5*l.*, and that associate members should pay 2*l.* 10*s.* An analysis of the accounts would show that the general expenditure of the Institution had risen from 13,500*l.* in 1918 to 16,000*l.* in 1919. With corrections for petty cash, &c., the rise reached nearly 4,000*l.* After this year there would be a shortage of 1,500*l.* to 2,500*l.*, which furnished an excellent reason for the increased subscription proposed. The present rates were small compared with those of other engineering institutions. The alterations were really necessary. Strong efforts were being made to start local branches, from which much advantage was expected. But the Institution must be prepared to give help to such branches.

Mr. Michael Longridge, referring to the proposed alterations to Bye-laws 1 and 2, felt that members should know the reasons which guided the council in proposing modifications. The bye-laws, as altered, prescribed, for members and associate members respectively, two classes of qualification, the age qualification and the attainment qualification. In the age qualification differentiation was introduced between those who had passed the associate membership examination and those who had not—an extension of the principle already applying. Since 1913 associate members who had passed the required examination were allowed to be elected up to the age of 27 years, while those who had not passed such examination were not to be elected until 30 years of age. The principle was a sound one, and there was no reason against extending it to full members. There were some who attained a position entitling them to be elected members at the age of 30, and there was no desire to raise the age for those men. Those men had not only practical qualification and workshop training, but also the theoretical training now so essential. Men who had only workshop experience to rely upon could only tackle satisfactorily the jobs lying within that experience, whereas the men with scientific training could use a smaller experience over a wider range. Therefore the man whose experience was only of the workshop must have a longer experience, and that constituted the reason for raising the age of members who had not passed the associate membership examination; for these it was proposed to raise the age from 30 to 35 years. He would say that the council had before them month by month application forms which stated the ages of the candidates, and the conclusion derived from experience of these forms was that the ages adopted were those most suitable. Mr. Longridge also mentioned the case of men who joined the Institution before the days of examination, and who, under the proposed bye-laws, as they stood, would not yet be eligible to become full members. The number of such men was small, and it was therefore suggested that they should have the right of taking the examination at the

present time or of coming in on showing that they had the necessary education and attainments.

Captain H. Riall Sankey, speaking on the subject of the regulation for the admission of graduates, said that the council did not propose any alteration in the limits of ages from 18 to 28, but they did propose that in certain cases graduates should remain such until the age of 33. The reason was that sometimes young men were not able to obtain posts which were regarded as qualifying for associate membership, in which case, at the age of 28, they would have to leave the Institution, returning, perhaps, at a later time. To bridge that gap, it was suggested that they should remain graduates up to the age of 33 years, and if they could not get a responsible job at that age, obviously they were not fitted to be engineers. To remove any temptation to remain graduates up to the age of 33 unnecessarily it was proposed that the subscription of a graduate after attaining his 28th year should be raised to that payable by associate members.

The chairman then moved that the amendments proposed by the council to bye-law No. 1 be adopted, Mr. Patchell seconding the motion.

Mr. G. W. Thompson moved, and Mr. P. O. Bonniwell seconded, that the proposed alteration of bye-law No. 1 be rejected. This was put to the meeting, and, on a show of hands, was lost, the original motion being subsequently carried.

The chairman next moved that the alterations in bye-law No. 2 proposed by the council be adopted, the motion being seconded by Captain Sankey. Under this motion no candidate could become an associate member until 27 years of age, and if he had not passed the associate membership examination until 33 years of age. There was no opposition to this proposal, and the motion was carried.

Mr. E. W. Moss then moved an amendment to the Council's proposals regarding Bye-law 3. It had struck him as remarkable that the number of graduates of the Institution was not larger than about 300. Some students attended college at as early an age as 16 years, and he could see no reason why the graduate membership of the Institution should not be open to all students of engineering in technical colleges. Many members had spoken to him about the proposed alteration, and practically all of them had regarded the age of 16 as too young, as it would involve mere boys being present at the meetings. He saw no disadvantage in youths of 16, keen enough to desire it, being admitted as graduates, and it would be a great benefit to such youths to be able to attend the meetings. Many present students would become leading engineers in the future, and if secured as members when young they would be less likely to relinquish membership later.

Captain Sankey, speaking on this amendment, regarded 16 years as too young an age for graduateship. Graduates should have a certain amount of experience in engineering, such as could not be expected of youths of 16. At the same time he, with other members of council, agreed with Mr. Moss in thinking that students of universities should be roped into the Institution when young. A way out of the difficulty was the establishment of a rank to be called, say, "junior graduates" or "students." The Institution of Electrical Engineers had such a rank. He would propose that the age of such rank should be from 16 to 19 years, giving an overlap of one year on the age at which a graduate could be elected. Such a change, however, could not be introduced without a change in the Articles of Association, for which a special meeting was necessary. He therefore asked Mr. Moss to withdraw his motion, leaving the meeting to request the council to form a committee. Captain Sankey then formally proposed that a committee be formed, to consider the question of establishing a junior grade of graduates. Mr. Moss having withdrawn his amendment, Mr. Patchell seconded the proposal put forward by Captain Sankey. The resolution was then put to the meeting and carried.

The chairman next proposed that the alterations made by the council in Bye-law 3 should be adopted. On being seconded by Captain Sankey, the proposal was carried *nem. con.* This alteration rules that no candidate can become a graduate after completing his twenty-sixth year, and that graduates who did not become qualified for election as associate members at an earlier date should be permitted to retain their position as graduates until 33 years of age.

The further consideration of the bye-laws was then postponed to the adjourned annual general meeting, which will be held on Friday, March 5 next.

### Election of Officers.

The ballot list for the election of officers having been opened by a committee of the Council, the following had been found to be elected: as President, Capt. H. Riall Sankey; as Vice-Presidents, Sir Robert A. Hadfield, Bart., and the Right Hon. Lord Weir; as Members of Council, Mr. Richard W. Allen, Sir George J. Carter, Dr. H. S. Hele-Shaw, Mr. Christopher W. James, Mr. Donald B. Morison and Sir Vincent L. Raven.

The Chairman then read a letter from Dr. Hopkinson, the retiring President, regretting his inability to be present to perform the last of his official duties and expressing to the members his regret that continued ill-health had precluded his being present at so many of the meetings during his year of office. Capt. Sankey, the new President, then took the chair.

Mr. Michael Longridge, Past-President, proposed a vote of thanks to the retiring President. He keenly realised the disappointment which, owing to his ill-health had awaited Dr. Hopkinson during the past year. Dr. Hopkinson's interest in the Institution could not be measured by his attendances at the general meetings; throughout the year Dr. Hopkinson had taken the keenest interest in the affairs of the Institution, assisting with his advice, and the Council were very much indebted to him. He would ask members to offer their thanks to Dr. Hopkinson for what he had done, coupled with a message of sympathy and their earnest wishes for his rapid recovery of health.

Dr. W. H. Maw, Past-President, seconded the motion. He was glad that the task of proposing the vote of thanks had been undertaken by Mr. Longridge, who had an intimate knowledge of Dr. Hopkinson's qualifications and the extreme interest the latter had taken in the Institution during the time of his presidency. To have been, during the past session, deprived of the presence of Dr. Hopkinson at the meetings had been a great loss to the Institution, but it was a still greater loss to Dr. Hopkinson that he had been prevented from attending.

The motion was carried with acclamation.

Mr. Longridge then proposed a vote of thanks to the Vice-Presidents who had taken the chair in the ex-President's absence. Dr. Hele-Shaw, in seconding the proposal, referred particularly to the assistance given by Mr. Mark Robinson, who had placed the finances of the Institution on a splendid business footing. Dr. Hele-Shaw also commented upon the illness of the Secretary, pointing to the latter's admirable execution of his duties over a period of nearly a quarter of a century, and he would ask members to send to Mr. Worthington an expression of their hope that he would soon be restored to health.

The President desired to add his testimony as to the excellence of Mr. Worthington's qualifications as Secretary. The Council deplored his breakdown, and hoped before long to see him restored to health.

The foregoing votes were put to the meeting and passed unanimously.

Major P. J. Cowan then proposed that Mr. Raymond Crane, F.C.A., be re-appointed to audit the accounts of the Institution. The resolution was seconded by Mr. Basil Joy, and, on being put to the meeting, was carried.

### Utilisation of Water Power.

It will be remembered that at the meeting held on January 23 last* a paper on "Recent Advances in the Utilisation of Water Power," by Eric M. Bergstrom, was read and partly discussed. As the hour was late, it was proposed by the President that further discussion should be deferred until the occasion of the adjourned annual meeting, but if any member, who would not be able to attend at that date, was present he had now an opportunity to speak.

Mr. A. E. L. Chorlton availed himself of the opportunity thus offered. He spoke on the question of the efficiency of the turbine, which he regarded as the principal point of the paper. The efficiency of the turbine had been stated by the author to have risen to the extent of 5 per cent. to 8 per cent., and he desired to ask Mr. Bergstrom what were the particular part or parts of the design the alteration of which had secured this increase in efficiency.

There was close analogy between the turbine pump and the turbine, the one having a reverse action to the other—and if, on the latest design, the suggested increase in the efficiency of turbine wheels of comparatively moderate capacity had been attained, it was reasonable to expect that similar gains could be incorporated, to a modified extent, in the turbine pump. One was, of course, a convergent and the other a divergent machine, and owing to that circumstance there was risk in applying the gains made in one to the other. The Francis turbine, with which the paper was chiefly concerned, was rarely used as a pump. He would therefore appreciate more details of the exact design of the improved turbine. The paper was compendious, but did not go much into the design of smaller parts; it dealt rather with main principles. He concluded by complimenting the author on the excellent form of his paper and expressed regret that the discussion of it had been taken in such a disjointed way.

The meeting was then adjourned until Friday, March 5th, after the announcement had been made that there would be an informal meeting on Friday, February 27, at 7 p.m., when a discussion on the "Education of the Engineer" would be opened by Mr. F. W. C. Dean.

### The Benevolent Fund.

The eighth general meeting of the members of the Incorporated Benevolent Fund of the Institution was also held on Friday evening last. The minutes of the previous meeting, held on February 21, 1919, were first read and confirmed. The President next moved the adoption of the report of the Committee of Management for the year 1919. Mr. L. St. L. Pendred thought that some effort should be made to bring the Fund to the attention of members generally. In the account the payments "by grants" only amounted to 144*l.* 10*s.*; he thought it incredible, in view of the distress prevailing during the last year or two, that the applications should not have led to grants totalling a larger amount. Mr. Patchell remarked that something could be said on both sides of the question, and it was felt, on the Committee, when considering applications, that a good many more people ought to be on the Fund. The difficulty was, however, to get at them, and the Committee hesitated to take really active steps in this direction, because the Fund was still so small. He was sure that more subscriptions would lead to more applications. Mr. Michael Longridge said that only 44 per cent. of the applications to the Relief Fund of the Institution of Surveyors made during the war came from those affected by the war. That showed that there was a large number of professional people in need of assistance, and that this need would continue. He felt that the grants habitually made were too small to be of much use, and he believed the Committee were coming to the conclusion that more should be done.

The report was adopted.

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* See Engineering, pages 140, 152, 191, 227 *ante*.

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**Shipbuilding in Germany.**—The Howaldt yard, in Kiel, has done considerably better during 1919 than during the previous year. The net profits being, respectively, 2,070,876 marks and 618,664 marks. The dividend was fixed at 12 per cent. for last year, as compared with 5 per cent. for 1918. The annual report states that the prospects for the current year are still uncertain. Piece work, which came to an end with the revolution, is being re-introduced, but there is a continued shortage of coal and raw materials. German shipowners are very reticent as regards the placing of orders for big vessels, but the company has succeeded in securing orders for several smaller boats, for which materials from former naval contracts have come in useful. It has, therefore, not been found necessary to discharge the workmen on a large scale.

# VERTICAL GAUGE PROJECTING APPARATUS; NATIONAL PHYSICAL LABORATORY

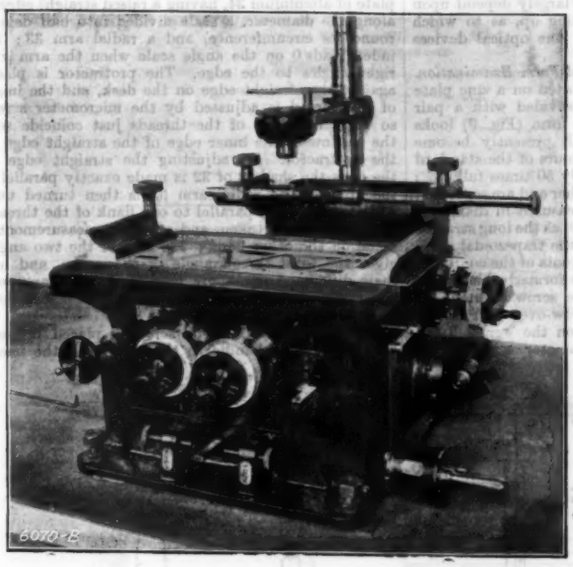



FIG. 1.

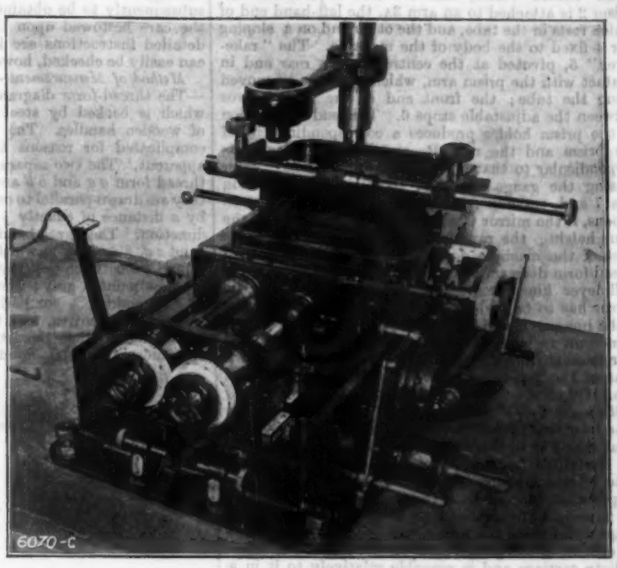
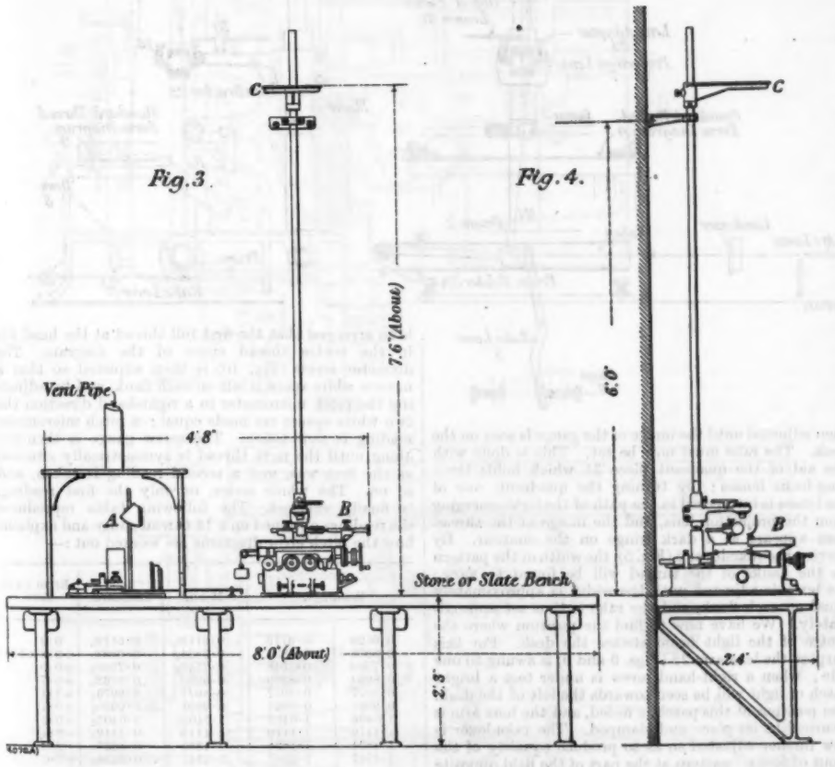



FIG. 2.




IN our recent articles on the work of the National Physical Laboratory we have repeatedly referred to the remarkable series of original measuring machines which were designed and constructed in the Metrology Department of the Laboratory to meet the war demand for accurate and expeditious gauge-measuring machines. The history of the development of these machines is characteristic of the period, and attention may be drawn to the dates, since attempts have been made to deprive the staff of the Laboratory of their well-earned credit for the origination of these ingenious machines. Up to the end of 1915 microscope apparatus was practically alone in use for inspecting screw plug gauges. By January, 1916, the first machine, producing an image of the thread magnified 50 times on a screen, designed and made in the Laboratory, was put in use for screw-gauge work; the diameter of the useful field was small, only 7 in. By March of the same year a horizontal type of projector having a field of 7 ft. had proved serviceable for testing not only screw gauges, but also profile plate gauges up to 1½ in. in length. This machine has been manufactured, and about 100 of these machines are in use in England, on the Continent and in America. An early experimental model of the next scheme, the vertical projector, was erected in the Laboratory in November, 1916. The vertical path of the light makes the latter machines far more convenient than the horizontal-projection apparatus. Of the several types of vertical-projection machines designed and manufactured since that date, four were in use in the Laboratory throughout 1918, and they were of invaluable service in dealing with the large numbers of gauges submitted—as many as 3,000 per week. Most of the members of the staff of the Metrology Department had some share in the design of the vertical projector; but by far the larger part of the credit goes, we may state, to Mr. E. M. Eden.

The machine we illustrate to-day is the standard type of vertical projector designed in the Laboratory in November, 1917. It is fitted with micrometer screws and allows, not only of inspecting screws as regards thread form, but also of taking complete measurements of the various elements on screws up to 2 in. in diameter, whilst in the comparison of thread form of screw gauges with the standard-form, gauges up to 6 in. diameter can be dealt with. The shadow protractor used in connection with these measurements is also a Laboratory instrument dating from January, 1917. Only one operator is required for manipulating the machine and for viewing the projected image.

Photographs of the vertical projection machine are reproduced in Figs. 1 and 2, annexed; Figs. 3 and 4 explain the general arrangement of the machine, in front and side views, on the bench; the optical scheme is shown by the diagrams Figs. 5 and 6, page 274; the general arrangements of the body of the machine are diagrammatically illustrated in Figs. 7, 8 and 9, while Fig. 10 explains the operation of the micrometer screws. The remaining diagrams, Figs. 12 to 14, will be referred to later.

The general idea is that the horizontal beam of light of an arc lamp is by a prism reflected vertically upward past the screw gauge which is horizontally supported on centres; the shadow image of the gauge is projected through a lens, which is mounted just above the screw, on to a horizontal mirror fixed 7½ ft. above the bench and thus about 6 ft. above the lens; the image is reflected downward again and is received on the desk or table of the machine—the desk is removed in the photograph, Fig. 2—in front of which the operator is seated. In the main the machine illustrated resembles that which we described in our issue of August 30, 1918, on page 221, when we also explained the use of the shadow protractor in performing measurements. We may, therefore, at once pass to a detailed description now under notice.

The machine may be said to consist of three main parts (Figs. 3 and 4): A, the arc lamp; B, the body of the machine, with its attachment for holding the lens and gauge and the micrometer screws; and C, the mirror which is carried on a horizontal bracket fixed to a vertical post. We begin with the optical scheme.

*Optical Arrangements.*—The beam from the arc lamp of 4 amperes passes through the condenser into the tube 1 (Fig. 5), half-way along which it strikes at 45 deg., the glass prism 2, which reflects the beam, upward in the direction of the gauge 3. In order to obtain a true image of the axial section of the screw the beam must be parallel to the rake of the thread, and the rays $R_1$ must hence be inclined to the vertical in the front view, but remain vertical in the side view. As shown in Figs. 5 and 6 the inclination is correct for illuminating the front of a right-hand screw; the inclination would have to be to the other side of

the vertical for the opposite side of the screw, and would be reversed for a left-hand screw. The amount of the inclination must be varied as the rake of the screw thread varies, and for this adjustment the prism 2 is attached to an arm 3A, the left-hand end of which rests in the tube, and the other end on a sloping bar 4 fixed to the body of the machine. The "rake-lever" 5, pivoted at the centre, has its rear end in contact with the prism arm, which can thus be moved along the tube; the front end of the lever moves between the adjustable stops 6. This endwise motion of the prism holder produces a corresponding tilt of the prism and the rays $R_1$ about a horizontal axis perpendicular to that of the gauge under test. After grazing the gauge the rays traverse the projection lens 7 and, travelling further upward, would come to a focus, if the mirror C were not interposed at half the focus height; the rays hence come to a focus at the level of the machine desk 8 on which the standard thread-form diagram 9 rests. The lens is of the No. 4 Dallmeyer kinematograph type. Like the lens the mirror has to be of best quality to prevent distortion of the image; the glass thickness of the mirror tapers from front to back so that the lesser image, produced by reflection from the lower plain glass face, is thrown clear of the main image, produced by upper silvered face. Other optical parts will presently be explained.

*Mechanical Arrangements* (Figs. 7 to 10).—The gauge 3 can be moved in the horizontal plane in two directions, parallel and at right angles to its axis. These motions are controlled by the micrometer screws. The bed-plate 10, which is provided with three levelling screws, supports an intermediate carriage or slide 11, which can move in a direction at right angles to the axis of the gauge under test; the upper carriage 12, which carries the centres of the gauge, rests on the top of the intermediate carriage and is movable relatively to it in a direction parallel to the gauge centres; the motions of the two carriages are guided by V-grooves and ⅜ in. balls. The lower slide 11 is operated from two micrometer screws 13 and 14 (Fig. 10). The nut of the screw 13 on the left is fastened to slide 11 and moves with it; the point of the micrometer screw, which is furnished with a hard-steel piece, butts against the stop 15 which is fixed to the bedplate 10. The nut of the right-hand screw 14 is fixed to the bedplate, and the carriage 11 has an abutment 16 which comes in contact with the point of screw 14. Thus the sliding carriage 11 is adjusted at the rear end of its motion by the micrometer 13 and at the forward end by the second micrometer 14. A third micrometer 17 (Fig. 9) controls the movement of the upper slide 12 in the pitchwise direction; the abutment for this micrometer is formed by a hardened steel face 18, fixed to the intermediate slide 11. The pitch of the micrometer screws is 0·05 in.; their dials are graduated to read to 0·001 in. and with the aid of the verniers readings can be taken to 0·0001 in. Two sets of V-grooves are provided for holding the centres; the front pair accommodates gauges up to 2 in. in diameter, and the rear pair allows of examining gauges up to 6 in. diameter for thread form, but on one side of the diameter only.

The front and back motion of the carriage 11 is worked by the intermediation of the throw-over gear placed to the right of the bed. A rocker arm 20, of the form of an inverted T (Fig. 7), pivoted at its centre, is connected to the carriage 11 by the link 21. The weight 19 (Fig. 9) placed at the end of a crank turning on the same pivot as 20, can be made to rest either on the front portion or on the rear portion of the T-piece. In our diagram it is resting on the rear part, and the slide is driven towards the back. The dashpot 22, at the rear of the machine, prevents the bumping of the micrometer screws against their abutment; it is adjusted by means of the milled screw head 23A (Fig. 7). Close contact between the screws and their abutments is secured by the weight 19 when the final settings are made. Similarly the weight 23, carried by a cord passing over a pulley, ensures contact between the pitch micrometer and its stop.

We can now supplement our description of the optical arrangements. The projection lens 7 is screwed into an adapter 24 (Figs. 5, 6 and 8) which itself screws into the bracket 25; this bracket is clamped to a sleeve 26 which is fitted to the short vertical post 27 at the rear of the bedplate. The sleeve can be rotated round the post, and the lens be swung out of position for inserting a gauge between the centres. When the lens is in position, the sleeve is located by the two vees at the bottom fitting on the through pin 28 (Fig. 7). The vertical bar 29 is screwed into the upper end of the post 26 and is steadied in its upper portion by a bracket from the wall. The mirror 30 is carried by a bracket clamped to the upper end of the vertical bar (Fig. 6); on the one side it is supported by a single pin, on the other side it is levelled by means of two screws.

*Setting-up the Machine.*—Before a machine is issued for use it is carefully tested at the Laboratory, especially for straightness of the two directions of motion of the gauge which should be parallel or square to each other and be in horizontal planes; the mirror and desk must also be horizontal, and the motion of the upper carriage be parallel to the line of centres. The accuracy subsequently to be obtained will largely depend upon the care bestowed upon the setting up, as to which detailed instructions are issued; the optical devices can easily be checked, however.

*Method of Measurement—Thread-Form Examination.*—The thread-form diagram is printed on a zinc plate which is backed by steel and provided with a pair of wooden handles. The thread form (Fig. 9) looks complicated for reasons that will presently become apparent. The two separate contours of the standard thread form $a\,a$ and $b\,b$ are exactly 50 times full size; they are drawn parallel to one another and are separated by a distance of exactly ½ in., measured in diametral direction. The zigzag band, as well as the long straight band $c\,d$, also ½ in. in width, and the trapezoidal spots $e\,f$ and $g\,h$ between the crests and roots of the contours, are now painted grey; they were formerly blackened in. In making a comparison the screw is mounted between the centres, and the throw-over gear is put in position so that the letter L on the weight 19 is uppermost. The left-hand micrometer screw 13 is

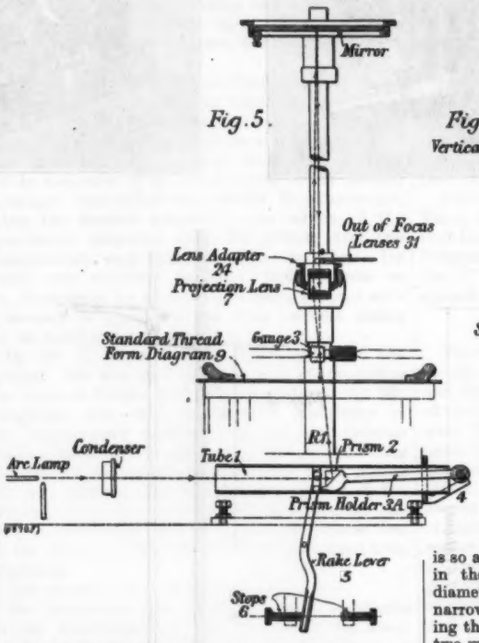



Fig. 5.

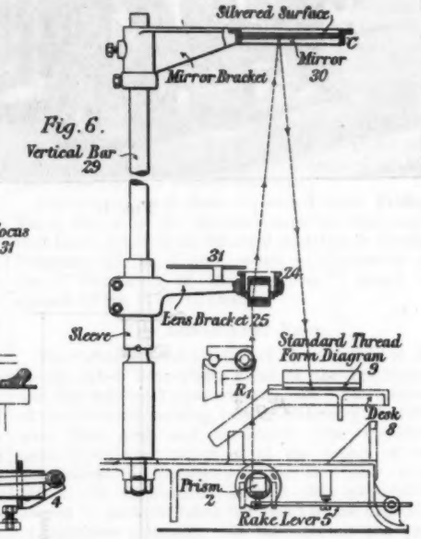



Fig. 6.

then adjusted until the image of the gauge is seen on the desk. The rake must now be set. This is done with the aid of the quadrant piece 31 which holds three long-focus lenses; by turning the quadrant, one of the lenses is interposed in the path of the light emerging from the projection lens, and the image of the thread then appears as a dark fringe on the contour. By moving the rake-lever 5 (Fig. 5), the width of the pattern on the flanks of the thread will be found to vary; the lever is adjusted until the width is approximately equal on each flank, and the rake is thus set approximately. We have now to find the position where the centre of the light beam strikes the desk. For this purpose the lens arm 25 (Figs. 6 and 9) is swung to one side; when a right-hand screw is under test a bright patch of light will be seen towards the left of the desk. The position of this patch is noted, and the lens arm is returned to its place and clamped. The rake-lever is now further adjusted so as to produce equality of the "out of focus" pattern at the part of the field opposite the centre of the beam. On turning the quadrant aside so as to remove the auxiliary lens, the image of the thread will appear clear and the definition equal on all the flanks.

The straight edge 29 (Fig. 7) forms a ledge at the back of the desk against which the diagram is held; the edge is pivoted at the right hand end; by means of an eccentric pin, fitted with a knurled head 30, its direction is adjusted at the other end; in this way the diagram is set so that the crests of the image just touch the edges $h\,h$ or $f\,f$ (Fig. 9) of the diagram; diagram and image will then be parallel to one another. For direct comparison with the lower contour $b\,b$ the diagram need afterwards only be shifted along the straight edge. Any excess metal will produce black overlapping portions; white spaces will appear where metal is missing. To bring these contrasts out well, the diagrams are, as already mentioned, printed dark grey, not black.

*Thread Angle.*—Thread angles are measured with the aid of the shadow protractor (Fig. 11), a semicircular plate of aluminium 34, having a raised straight edge 32 along the diameter, a scale divided into half degrees round its circumference, and a radial arm 33; the index reads 0 on the angle scale when the arm is at right angles to the edge. The protractor is placed against the straight edge on the desk, and the image of the thread is adjusted by the micrometer screws so that the crests of the threads just coincide with the shadow of the inner edge of the straight edge on the protractor. By adjusting the straight edge on the desk the shadow of 32 is made exactly parallel to the crests. The radial arm 33 is then turned until one of its edges is parallel to one flank of the thread; a reading is now taken, and a similar measurement is made on the other flank; the sum of the two angles gives the total thread angle of the gauge, and half their difference represents the "out of squareness." The measurements are repeated at several places along the thread.

*Pitch Measurement.*—The screw is placed between centres with the handle to the right, and the image is so arranged that the first full thread at the head fits in the centre thread space of the diagram. The diameter screw (Fig. 10) is then adjusted so that a narrow white space is left on each flank, and by adjusting the pitch micrometer in a right-hand direction the two white spaces are made equal; a pitch micrometer reading is now taken. The screw gauge is then fed along until the next thread is symmetrically situated as the first was, and a second reading is taken, and so on. The whole series, or only the first reading, is finally checked. The following table reproduces the readings obtained on a 14-thread gauge and explains how the pitch error diagrams are worked out:—

| Readings. | | Mean. | Standard. | Error from Zero. |
|---|---|---|---|---|
| 0·6120 | 0·6119 | $0·6119_5$ | $0·6119_5$ | 0·0 |
| 0·6835 | 0·6834 | $0·6834_5$ | $0·6833_7$ | $+0·8\times10^{-4}$ |
| 0·7549 | 0·7548 | $0·7548_5$ | $0·7548_0$ | +0·5 |
| 0·8263 | 0·8263 | 0·8263 | $0·8262_3$ | +0·7 |
| 0·8977 | 0·8977 | 0·8977 | $0·8976_6$ | +1·1 |
| 0·9691 | 0·9691 | 0·9691 | $0·9690_9$ | +0·1 |
| 1·0406 | 1·0405 | $1·0405_5$ | $0·0405_2$ | +0·3 |
| 1·1119 | 1·1119 | 1·1119 | $0·1119_4$ | −0·4 |
| 1·1834 | 1·1834 | 1·1834 | $0·1833_7$ | +0·3 |
| 1·2547 | 1·2547 | 1·2547 | $0·2548_0$ | −1·0 |

The figures in the column headed "standard" are obtained by taking the first mean reading and adding to it in succession $\frac{1}{14}$ in., $\frac{2}{14}$ in., $\frac{3}{14}$ in., &c. The errors given in the last column are plotted in the diagram, Fig. 12, yielding the curve $p\,q\,r$. If the micrometer screw of the machine had itself no error, this curve would be the pitch error curve of the gauge; when the micrometer has a calibration curve like $s\,t\,u$ (Fig. 13), however, the $p\,q\,r$ curve has to be corrected. The portion of the micrometer used in the case illustrated extended from 0·6 in. to 1·25 in., and this portion of $s\,t\,u$ is plotted in the curve $s_1\,t_1\,u_1$ of Fig. 12; the true pitch error then is the difference between the two curves, represented by the curve $v\,w\,x$ in Fig. 14.

*Measurement of Full and Core Diameters.*—A plain

# VERTICAL GAUGE PROJECTING APPARATUS; NATIONAL PHYSICAL LABORATORY.

Fig. 7. SIDE VIEW.

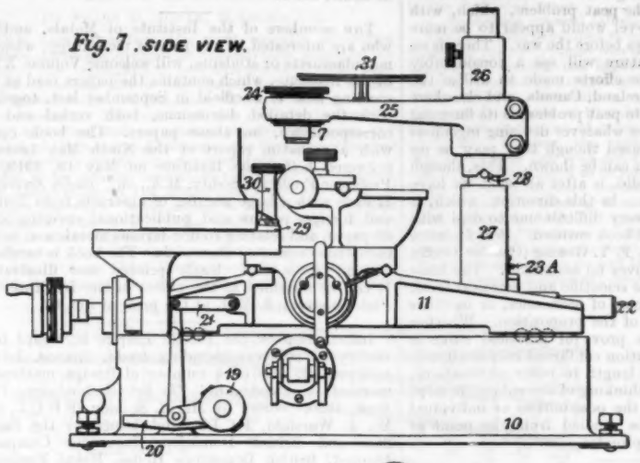



Fig. 8. FRONT VIEW.

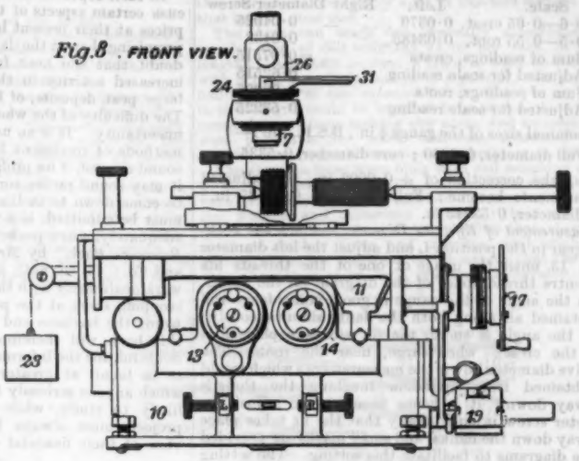



Fig. 3. PLAN.

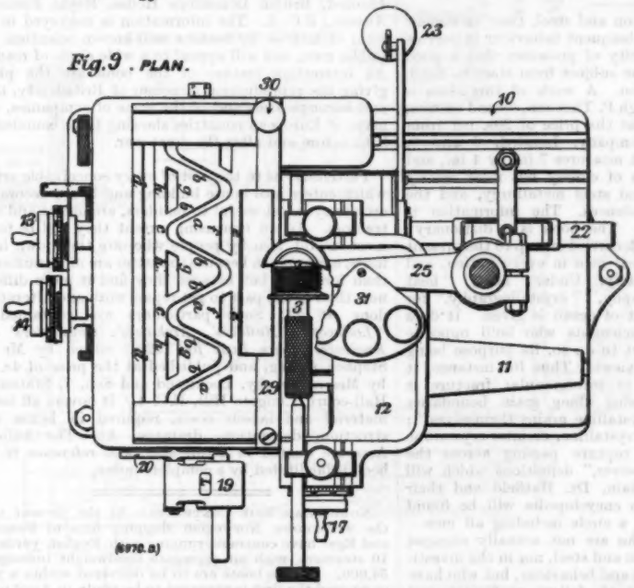



Fig. 11.

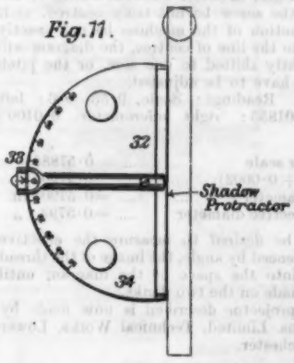
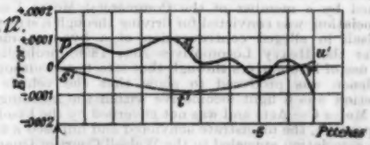



Fig. 12.




Reading 0·612

Fig. 13.

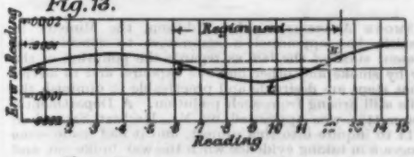



Fig. 14.

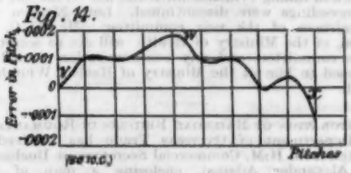
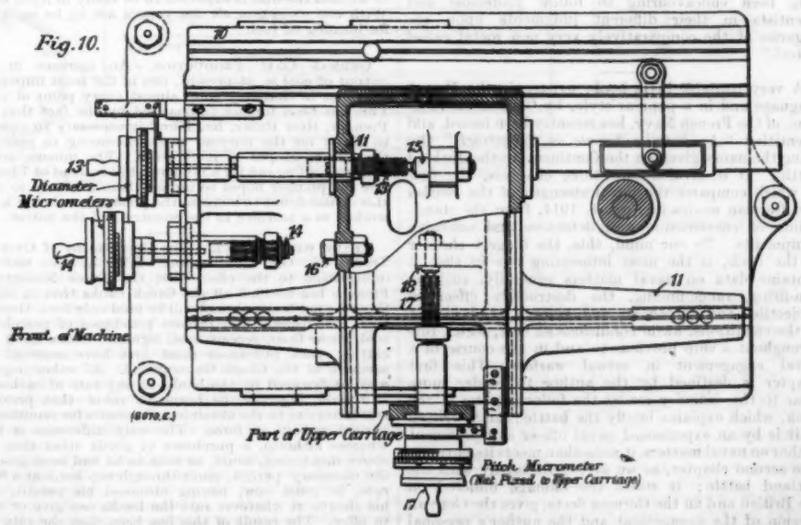



Fig. 10.




plug gauge of known size is required for setting-up the machine. This plug having been mounted between centres, the rock-over gear (Figs. 7 and 9) is turned to the left, and the left micrometer screw 13 is adjusted to bring the edge of the image in coincidence with the edge *d d* of the straight band. The rock-over gear is now thrown over to the right; the other side of the plug is seen, and its edge is brought up to *c c* by means of the right-hand diameter screw. The two dial readings are noted, together with the reading on scale of the ruled bar seen to the left of screw 13 (Fig. 10). An example will explain: actual size of plug, 0·59965 in.; readings: scale 0·6 in., left diameter screw, 0·0204; right diameter screw, 0·02905; sum, 0·04945. The reading on the scale indicates that the size is approximately 0·6 in., and we must add 0·55 in. to the sum of the readings, which gives us 0·59945 in. This reading is 0·0002 in. smaller than the actual size of the plug (0·5996, above), so that this amount of 0·0002 in. must be added to all readings in the neighbourhood of 0·6 in. to find the true diameter.

The plug is now replaced by the screw gauge to be measured. With the rock-over gear in left position the image is set to make the crests coincide with the edge *d d*; the left micrometer 13 is read. The gear is changed over to the right, the rake is also changed over, and the crest is set to edge *c c*. The operation is repeated,

setting the roots of the threads to the diagram. For example. Readings :—

| Scale. | Left. | Right | Diameter Screw |
|---|---|---|---|
| 0·6—0·65 crest, | 0·0379 .... | .... | 0·04025 |
| 0·5—0·55 root, | 0·03485.... | .... | 0·0438 |
| Sum of readings, crests | .... | .... | =0·07515 |
| Adjusted for scale reading | .... | .... | 0·62515 |
| Sum of readings, roots | .... | .... | =0·08225 |
| Adjusted for scale reading | .... | .... | 0·53225 |

The nominal sizes of the gauge ½ in., B.S.F., are :—

Full diameter, 0·0250 ; core diameter, 0·5335.

Making the correction of + 0·0002 in., the adjusted measurements become : Full diameter, 0·62535 in. ; core diameter, 0·53245 in.

*Measurement of Effective Diameter.*—Place the rock-over gear in the position L and adjust the left diameter screw 13 until the image of one of the threads fits the centre thread space of the diagram on the flanks. When the angle of the gauge is good, coincidence will be obtained all along both the flanks simultaneously ; when the angle is small, the fit will take place first near the crest ; when large, near the roots. The effective diameter now is the measurements which would be obtained from cylinders touching the threads half-way down, it is hence necessary to adjust the diameter screw in such a way that the fit takes place half way down the flanks, and small marks are provided on the diagrams to facilitate this setting. The setting having been made on the one side, the gear and the rake are changed over to obtain a similar setting on the other side. If the screw be not truly centred, or if the diametral motion of the machine be not exactly at right angles to the line of centres, the diagram will have to be slightly shifted to one side, or the pitch micrometer will have to be adjusted.

For example : Readings : Scale, 0·55—0·6 ; left micrometer, 0·01855 ; right micrometer, 0·0100 ; sum, 0·02885.

| | | | |
|---|---|---|---|
| Adjusted for scale | .... | .... | 0·57885 |
| Corrected (+ 0·0002) | .... | .... | 0·57905 |
| Effective diameter | .... | .... | =0·57905 in. |
| Nominal effective diameter | .... | .... | =0·5793 ,, |

If it should be desired to measure the effective diameter as influenced by angle, the image of the thread should be fed into the space of the diagram until contact is just made on the two flanks.

The vertical projector described is now made by Messrs. J. Cussons, Limited, Technical Works, Lower Broughton, Manchester.

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Motor Appeal Case.—The driver of a steam tractor, owned by a member of the Commercial Motor Users' Association was convicted for driving through a street in Walsall in alleged contravention of a bye-law made under the Heavy Locomotives Act, 1898, prohibiting the use of locomotives through that street, and although evidence was produced to show that the vehicle in question was a light locomotive within the meaning of the Motor Car Acts and was not governed by the bye-law in question, the magistrate convicted and imposed a fine. The association appealed to the Walsall Court of Quarter Sessions, when the Recorder allowed the appeal.

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Smoke Abatement.—Dr. Addison, the Minister of Health, has appointed a committee to consider the present state of the law as regards the pollution of the air by smoke and other noxious vapours, and to advise what steps are desirable and practicable to diminish the evils still arising from such pollution. A Departmental Committee was appointed by Mr. Herbert Samuel in 1914 to inquire into this subject, and it had made some progress in taking evidence when the war broke out and its proceedings were discontinued. Lord Newton will be chairman of the new committee. Mr. E. C. H. Salmon, of the Ministry of Health will act as secretary to the committee, and any communication should be addressed to him at the Ministry of Health, Whitehall, S.W. 1.

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Restoration of Railroad Bridges in Roumania.—The Department of Overseas Trade has received a despatch from H.M. Commercial Secretary at Bucharest (Mr. Alexander Adams), enclosing a map of the Roumanian railroad system showing the number of bridges destroyed wholly or in part by the enemy. A large number of these bridges have been temporarily repaired, but there is a very large scope for the activities of any British firms desiring contracts for their further repair and for the construction of others. Outline drawings of the bridges and particulars of the work involved, can be procured from the Ministry of Public Works by interested firms who will send their representatives to Roumania for the purpose, whilst the map referred to can be examined in the Department on application to Mr. Dempster (Room 50, Telephone Extension No. 402). At the present moment it would be necessary for British contracting firms to accept such conditions of payment as Roumanian Treasury Bonds, payable in sterling at two or even three years' date. British firms desirous to take any steps in the matter could address the Minister of Public Works, Bucharest, Roumania and a notification to the Department of the action so taken will be appreciated.

## NOTES ON NEW BOOKS.

In their report the Nitrogen Products Committee discuss certain aspects of the peat problem, which, with prices at their present level would appear to be more promising than in the days before the war. There is no doubt that the near future will see a considerably increased activity in the efforts made to utilise the large peat deposits, of Ireland, Canada, and elsewhere The difficulty of the whole peat problem is its financial uncertainty. It is no use whatever devising ingenious methods of treatment based though they may be on sound science, if no profit can be shown. This, though it may sound rather sordid, is after all what we have to come down to in life. In this direction, which, it must be admitted, is a very difficult one to deal with adequately, a new pocket book entitled "*Peat Industry Reference Book*," by Mr. F. T. Gissing (Charles Griffin and Co. ; 7*s.* 6*d.* net), gives no assistance. The little work deals fairly with the scientific and practical facts, stopping short at the point of economics, or in other words the business end of the proposition. Whether this book will therefore prove of practical value is doubtful, for the information contained in it is already to be found at greater length in other publications, which anyone seriously thinking of the subject is more likely to study, while the possibilities of individual projects must always be studied from the point of view of their financial promise.

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The manufacture of iron and steel, their treatment when made and their subsequent behaviour in service involve such a multiplicity of processes that a good encyclopedia covering the subject from start to finish is a welcome publication. A work of this class is "*Iron and Steel*," by Hugh P. Tiemann, second edition, which can be obtained at the price of 20*s.* net from the Hill Publishing Company, Limited, 6 and 8, Bouverie-street, E.C. It measures 7 in. by 4 in., and contains over 500 pages of closely but most clearly printed data on iron and steel metallurgy, and the allied industries and sciences. The information is arranged alphabetically. The book is a dictionary ; it simply records the work carried out up to the present by scientists and practical men in every nation, and it does so very completely. Under "heat," "heat treatment," "metallography," "crystallography," for example, a large amount of detail is given. It does not arbitrate between scientists who hold opposite views, nor is it its object to do so, its purpose being simply to record those views. Thus for instance, it states that "granular or intergranular fracture is caused by rupture passing along grain boundaries instead of across the crystalline grains themselves" ; and "crystalline, trans-crystalline, or inter-crystalline fracture is caused by rupture passing across the crystalline grains themselves," definitions which will please both Dr. Rosenhain, Dr. Hatfield and their respective schools. This encyclopedia will be found useful by a wide circle, a circle including all men—and they are many—who are not actually engaged in the manufacture of iron and steel, nor in the investigation of their properties and behaviour, but who have long been endeavouring to follow professors and scientists in their different judgments upon the vagaries of the comparatively very new metal called "steel."

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A very readable little book, written in the French language and in a popular style, by Captain A. Poidloué, of the French Navy, has recently been issued, and is entitled "*La Bataille Navale du Skagerrack*," this being the name given on the Continent to the Jutland battle. It is divided into three chapters, the first of which compares the naval strength of the British and German navies in August, 1914, from the standpoints of construction and defensive and offensive equipments. To our mind, this, the longest chapter in the book, is the most interesting one in that it contains data on naval matters generally, such as gun-firing, range-finding, the destructive effect of projectiles and torpedoes, and gives a good insight in the conditions, awful conditions at best, which rule throughout a ship previous to and in the course of a naval engagement in actual warfare. This first chapter is destined by the author to render more clear to the ordinary reader the following one in the book, which explains briefly the battle ; and, written as it is by an experienced naval officer and proficient author on naval matters, it more than meets its purpose. The second chapter, as we say, deals briefly with the Jutland battle ; it states the damage inflicted on the British and on the German fleets, gives the German version of the engagement and the author's personal opinions. The book is written without any partiality, and concludes by stating that the success of the British Fleet was incontestable, although incomplete ; whilst the German Fleet, compelled to accept an unequal fight which her lack of speed did not allow her to evade, carried out a very honourable retreat. We believe a translation in English of this popular work would be well received in this country. It is published at the price of 3 francs by "Editions et Librairie," 40, Rue de Seine, Paris.

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The members of the Institute of Metals, and all who are interested in non-ferrous metallurgy, whether manufacturers or students, will welcome Volume XXII of the Institute, which contains the papers read at the meeting held in Sheffield in September last, together with the detailed discussions, both verbal and by correspondence, on those papers. The book opens with a verbatim report of the Ninth May Lecture, delivered before the Institute on May 19, 1919, by Professor Frederick Soddy, M.A., on "*Radio Activity.*" It ends with a large number of abstracts from British and foreign papers and publications, covering over 60 pages, and relating to non-ferrous metals and to the industries connected therewith. The book is carefully edited ; it is also clearly printed and illustrated. It can be obtained at the offices of the Institute, 36, Victoria-street, S.W. 1, at the price of 31*s.* 6*d.*

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Information on the British Empire in regard to a variety of subjects including trade, finance, labour and politics, also on a number of foreign matters of moment, is published in "*The British Dominions Year Book*, 1920," edited by Mr. E. Salmon, F.R.C.I., and Mr. J. Worsfold, F.C.I.S., and issued by the Eagle, Star and British Dominions Insurance Company, Limited, British Dominions House, Royal Exchange Avenue, E.C. 3. The information is conveyed in the form of articles by various well-known scientists and public men, and will appeal to a wide circle of readers. An interesting feature of the book are the plates giving the reproduction in colour of British city, town and borough arms and of the arms of companies, also maps of European countries showing their boundaries, both before and after the great war.

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Particulars as to the cost of every conceivable article which enters into house building and house decoration are always most useful to builders, architects and contractors. To an increasing extent they will be found most useful also by people who are their own landlords, not so much because the latter are more numerous than formerly, but because they find it more difficult now than in the past to get repair work and alterations done at all. Such particulars are contained in "*Lockwood's Builders', Architects', Contractors' and Engineers' Price Book for* 1920," edited by Mr. R. Stephen Ayling, and published at the price of 4*s.* net by Messrs. Crosby, Lockwood and Son, 7, Stationers' Hall-court, Ludgate Hill, E.C. 4. It covers all items, material and labour costs, required in house construction, decoration, drainage, &c. The building Acts are quoted in detail also, and reference to the book is facilitated by a complete index.

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Norwegian Ship Contracts.—At the present time the well-known Norwegian shipping firm of Fearnley and Eger have contracts running with English yards for 10 steamers, with an aggregate deadweight tonnage of 54,000. All the boats are to be delivered within a year or so, and the first is expected to be ready in April next. With one exception all the vessels are to be equipped for burning oil fuel.

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German Coal Production.—An increase in the output of coal is, at present, one of the most important problems in Germany from almost every point of view. This has been further emphasised by the fact that the Premier, Herr Bauer, has found it necessary to proceed to Essen for the purpose of endeavouring to persuade the miners to put in more work. The miners are at present holding out for a 6-hours' shift instead of 7 hours, but the premier hopes to induce them not only to drop this demand, but to increase the present number of hours worked as a sacrifice to the country and the nation.

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Trade with Greece.—The Department of Overseas Trade, 35, Old Queen-street, S.W. 1, have received information to the effect that the Greek Ministry of Finance has notified all the Greek banks that in future Government funds abroad will be used only for : Government purchases ; and private purchases of petroleum, coal, sugar flour, cereals, rice, legumes, frozen meat and cattle ; such purchases must first have received the sanction of the Greek Government. All other imports may be financed by the banks at any rate of exchange. It should, however, be borne in mind that previous regulations as to the obtaining of permits for remittances abroad remain in force. The only difference is that whereas hitherto, a purchaser of goods other than the above-mentioned, could, as soon as he had been granted the necessary permit, remit through any bank at a fixed rate, he must now, having obtained his permit, buy his cheque at whatever rate the banks can give or wish to offer. The result of this has been that the rate has fallen to about 30 drachmas to the 1*l.*, and a further fall is not improbable. In these circumstances, and in view of possible consequent developments, it is suggested that United Kingdom firms would be well advised to exercise caution in shipping goods on consignment, or even for cash against documents, and that for the present the safest method of settlement would be by means of confirmed bank credits.

# THE "LIGHT RAILWAYS" OF THE BATTLE FRONT IN FRANCE.*

By FRANK G. JONAH, M.Am.Soc.C.E.

THIS paper describes the most recently developed method of transportation in the advance sector of an army. The organisation and execution of this work in the American Army was almost entirely in charge of engineers from civil life, many of whom were members of the society. The object of this paper is to describe their activities and to present to the profession one feature of the many engineering works that were executed so successfully by the Americans in France.

The notes are the results of the writer's experience and observation in the construction and operation of "Light Railways" while acting as Major of the Twelfth Engineers (Railway), U.S.A., assigned to the British Army, and serving on the Picardy front from August 21 to October 27, 1917, and from that time until December 16, 1918, as Chief Engineer of the Department of Light Railways of the American Expeditionary Forces.

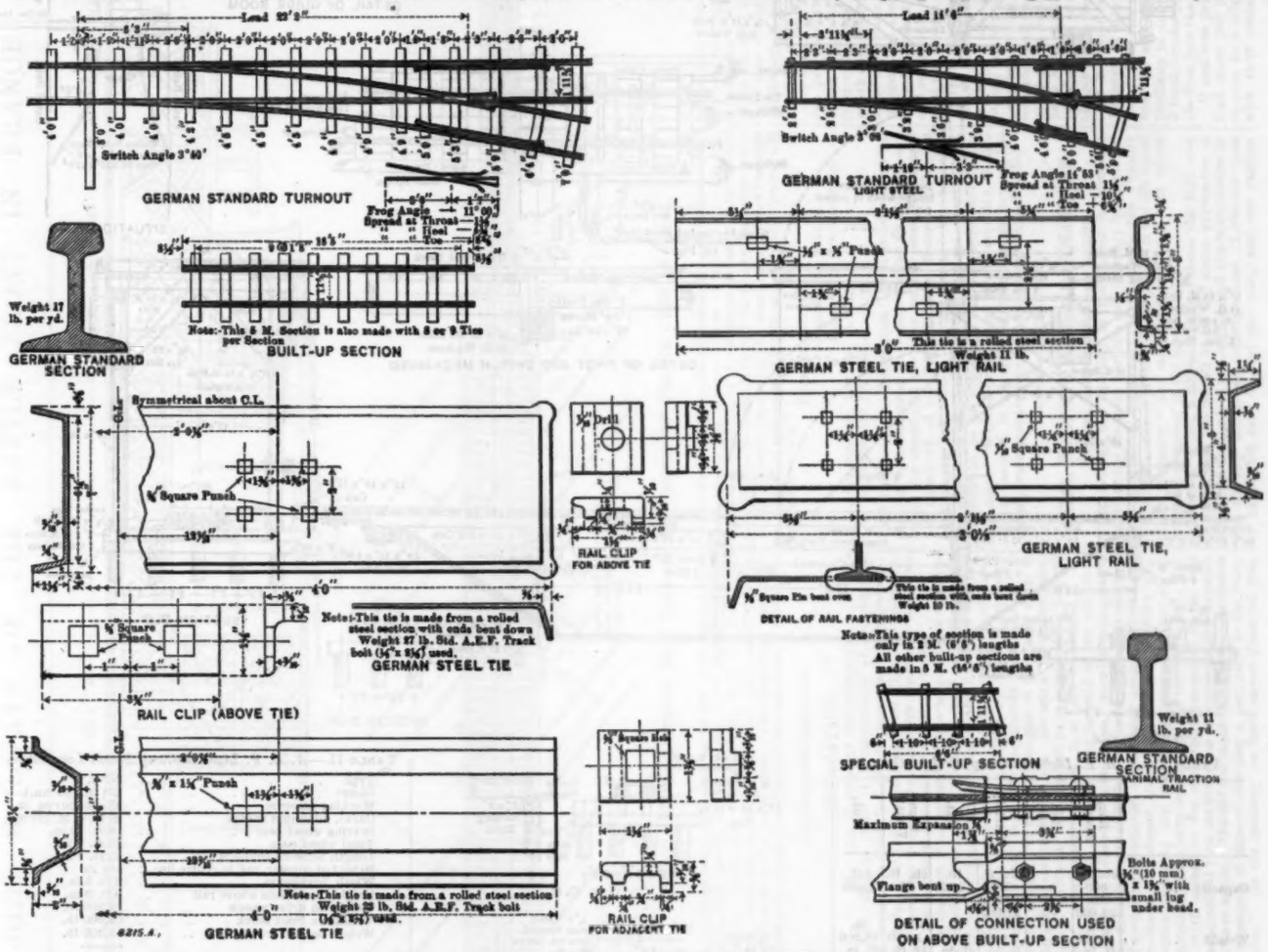

GERMAN STANDARD TURNOUT
Switch Angle 3° 40'
Frog Angle 11° 09'
Spread at Throat — 1½"
" " Heel — 2½"
" " Toe — 1½"
Lead 22'2"
Weight 17 lb. per yd.
GERMAN STANDARD SECTION
Note:-This 5 M. Section is also made with 8 or 9 Ties per Section
BUILT-UP SECTION
GERMAN STANDARD TURNOUT
LIGHT STEEL
Switch Angle 3° 58'
Frog Angle 14° 55'
Spread at Throat 1¼"
" " Heel — 10"
" " Toe — 1½"
Lead 11'6"
GERMAN STEEL TIE, LIGHT RAIL
Weight 11 lb.
This tie is a rolled steel section
Symmetrical about C.L.
⅞" Square Punch
RAIL CLIP (ABOVE TIE)
Note:-This tie is made from a rolled steel section with ends bent down
Weight 27 lb. Std. A.E.F. Track bolt (⅝"x 2¼") used.
GERMAN STEEL TIE
⅞" Drill
RAIL CLIP FOR ABOVE TIE
GERMAN STEEL TIE, LIGHT RAIL
⅞" Square Punch
⅞" Square Pin bent over
This tie is made from a rolled steel section with ends bent down
Weight 19 lb.
DETAIL OF RAIL FASTENINGS
⅞" x 1¼" Punch
Note:-This tie is made from a rolled steel section
Weight 29 lb. Std. A.E.F. Track bolt (⅝"x 2¼") used.
GERMAN STEEL TIE
RAIL CLIP FOR ADJACENT TIE
Note:-This type of section is made only in 2 M. (6'6") lengths
All other built-up sections are made in 5 M. (14'6") lengths
SPECIAL BUILT-UP SECTION
Weight 11 lb. per yd.
GERMAN STANDARD SECTION
ANIMAL TRACTION RAIL
Maximum Expansion ¾"
Flange bent up
Bolts Approx. ¾"(10 mm) x 1¾" with small lug under head.
DETAIL OF CONNECTION USED ON ABOVE BUILT-UP SECTION

FIG. 1.—DETAILS OF GERMAN LIGHT RAILWAY TRACK.

The "Light Railway" was a development of the great war, and was gradually extended in scope and importance until, at the close of hostilities, the mileage of the lines ran into the thousands. These railways were among the principal agencies of transportation.

It was found by the British, in 1916, that the transportation of supplies, necessary for the dense concentration of men at the front, could not be accomplished satisfactorily on the highways, and that some supplementary means of conveyance were necessary; therefore, orders were given for the development of a comprehensive system of "Light Railways" for the following primary reasons:—

1. To relieve the highways of traffic. In addition to the wear and tear on motor transport and the excessive use of gasoline, the wear on the roads was leading to a heavy traffic in road material, so that a large part of the traffic hauled by motor trucks was road material (crushed stone or gravel) to repair the damage which their own traffic was creating; and, consequently, there would be a great saving in labour in maintaining the roads if other means of transportation were developed.

2. To assist in a rapid advance over shell-torn areas when the roads were useless for motor transport and little better for horse transport.

3. To convey road material for the rapid repair of roads in the destroyed zones.

4. To reduce manual labour at the front.

The lines were developed so completely that, eventually nearly all heavy material was transported by the "Light Railways," leaving the highways clear for light, fast-moving automobiles, trucks and ambulances.

The railhead, or terminus, on the standard-gauge line was usually 8 miles or 10 miles back of the front line—far enough to be out of range of the enemy's ordinary shell fire. Between the railhead and the front, the standard-gauge line was generally destroyed by enemy operations, oftentimes as he retreated.

At the railhead were concentrated the supplies for a certain sector, consisting of ammunition, rations, forage, road material, building material, fuel, barbed wire, fence pickets, concrete material, culvert pipe, plank, track material, tools—in short, everything necessary for the sustenance of troops and for their means of offensive and defensive operations; and it was the function of the "Light Railways" to carry these supplies to the forward battery positions and front line trenches.

The lines were also used in moving troops up to the front, bringing back the relieved troops to their rest areas and the wounded from the front, and extensive use was made of these lines in salvage operations. The extent to which they were developed can be readily expressed by stating that for every mile of front which an army held, there were 10 miles of light railway supplying it.

The gauge of track used by all the armies on the Western Front, including the German Army, was 60 cm. (23⅝ in.), usually laid 2 ft. by the British and Americans. There was great advantage in this uniformity of gauge, as it permitted interchange of equipment among the allies and the immediate use of the captured German tracks after successful offensives.

In a general way, the characteristics of the lines on the different army fronts were similar. Grades of 3 per cent. and curves with a radius of 30 m., were used to facilitate rapid and easy construction. Embankments were made with 9-ft. crown cuts, with a 14-ft. base at sub-grade. The French track was of built-up sections, 5 m. long, the rail weighing 9 kg. per metre, with steel ties, 1 m. long, riveted to the rail.

The British used a rail weighing 20 lb. per yard. A certain amount of track was laid in short sections bolted to steel ties, but the greater part was laid with rails at least 24 ft. long, on wooden ties, 4 in. by 6 in. by 4 ft. 6 in., as it was found that track laid on wooden ties was much more easily kept in line and surface than that laid on steel ties.

The American track was generally constructed on wooden ties, of rail weighing 25 lb. per yard, in 30-ft. lengths. A certain amount of track in built-up sections, with a rail, 5 m. long, bolted to steel ties, was kept on hand for use at the extreme front. Sections of track in this length could be handled by a squad of men and coupled up without making any noise, and consequently were preferable for work near the trenches. Such sections also had advantages when building at night.

The German lines were built with rail weighing about 17 lb. per yard, on steel ties, bolted to the rails. They were extremely well built, and had a greater mileage than the French and American Armies. Their extensive use of these railways was due to the fact that they were short of rubber tyres and gasoline, and could not depend on motor transport to the extent that the allies did; but they were in a position to develop steam railway transportation, as they held the coal and steel districts of France and Belgium.

The Germans had one type of built-up track, which had some advantages. One end of the 5-m. section had a pair of bars with a hooked projection, while the other end had the flange of the rail bent up. In laying track, the hooked bar engaged the bent-up flange of the last section. This enabled the track to be connected on the grade with great rapidity and without noise. Details of this track are indicated in Fig. 1 above.

The speed with which tracks could be constructed by the different allied armies was practically the same. In September, 1917, the British stated that the construction of 1 mile of track, including ballasting, required 2,100 man-days of labour. The "French Manual of Light Railway," issued in April, 1918, states that their average had been ¾ m. per man per day, which is equivalent to 2,146 man days.

On the American front, the most important line, and the best constructed, was the connection between the central shops and storage yards at Abainville, and the front line system at the Sorcy railhead, a line 18½ miles long, on which the average speed of construction was 2,640 man-days per mile. As this line, together with the shops and yards at Abainville, and the Sorcy railhead, was the most important light railway job constructed by

* Abstract of a paper to be read before the American Society of Civil Engineers, New York, on March 3.

the American forces, and as several interesting engineering problems were presented in their construction, they will be described in some detail. The location for the central shops and storage yards of the "Light Railway" system was a matter for careful deliberation. It was necessary to find a location that would afford ample space for a large yard, with standard-gauge rail connection, and preferably canal connection as well. Abainville, 2 km. north of Gondrecourt, was recommended by the writer, in March, 1918, as a suitable location for shops and yards, which recommendation was approved. Subsequent events proved it to be a most desirable location, as it was directly behind the St. Mihiel and Argonne fronts, on which the greater part of the American operations were conducted. Abainville was 35 km. back of the line, and was not within the area usually bombed by the Germans.

The shops were designed for the repair of "Light Railway" locomotives and gasoline tractors and for the assembly and repair of freight equipment; and the yards were designed for the storage of track and bridge material. The whole plant covered an area of 116 acres. The track arrangement was such that material coming up from the ports on standard gauge was unloaded in the storage yard and subsequently taken to the front, as required, on the "Light Railways."

The shop buildings consisted of the Austin type of steel building, and were erected by the American troops, under the direction of a superintendent of the Austin Company, who had been sent over for that purpose. The buildings were of steel framework, boarded in with lumber obtained in France. The roof was boards covered with prepared roofing. The buildings were generally 40 ft. wide, 200 ft. long, and included an erecting shop, machine shop, gas engine and auto repair shop, planing mill, two storehouses, car shop, foundry, blacksmith shop, power-house and oil-house.

In the construction of the line leading from these shops to the Sorcy railhead, it was stipulated by the French authorities, that there should be no level crossings of the standard-gauge railways and no interference with navigation on the canals.

The line was projected on the French standard contour maps 1 to 20,000, a study of which showed the feasibility of a line with grades not to exceed 3 per cent. An examination of the route showed that the necessary crossings of standard-gauge tracks could be made under the main line viaducts or through large culvert openings. These points were selected as the governing conditions of the location, and the line was run accordingly. It was found that the French maps were extremely accurate—the summit elevations checked out exactly—the grade line and work was just what was expected.

It was necessary to cross the Marne-Rhine Canal at Void. The limited room for the 60-cm. line in this town necessitated crossing the canal at an angle of 68 deg., requiring a span of about 28 ft. to preserve the standard 6-m. width of waterway at right angles. Fortunately, the American engineers had some bridge stringers, 8 ft. by 16 ft. by 28 ft., which had been sent over from the United States. The writer designed a counter-weighted lift bridge with this material, which could be operated by one man. This proved so successful, that a standard plan was made for lift bridges, and as it was expected that most of the canal crossings could be constructed at right angles, a complete bridge was built and

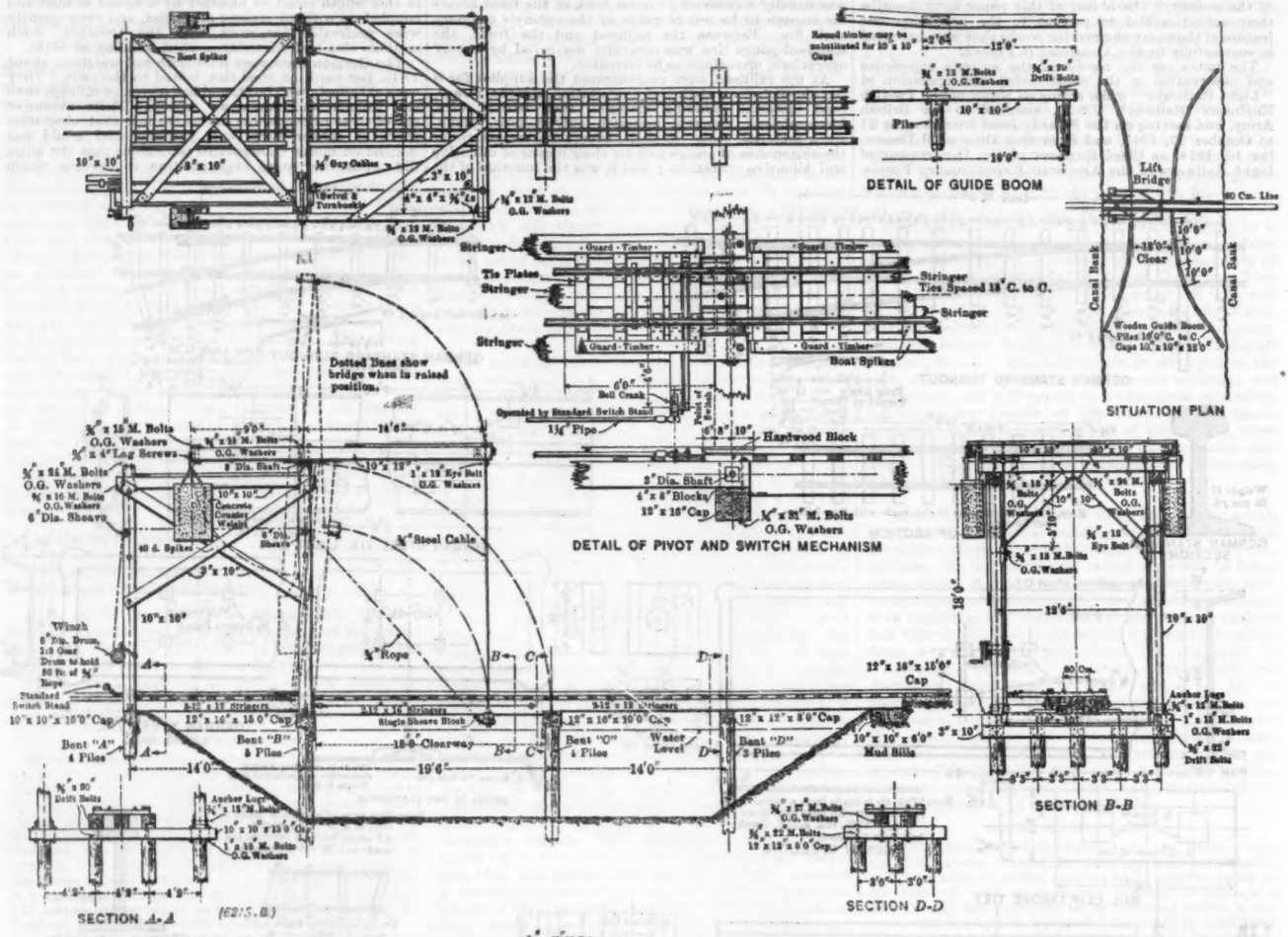



FIG. 2. DETAILS OF LIFTING BRIDGE FOR CANALS.

TABLE I.—*A. E. F. Light Railway Freight Cars.*

| — | Box, Covered. | Box, Open Top | Gondola. | Flat. | Dump V-shape | Tank. |
|---|---|---|---|---|---|---|
| Capacity .. .. | cb. ft. 600 lb. 22,000 lb. | — | cb. ft. 210 lb. 22,000 lb. | lb. 22,000 | cb. ft. 27 | gal. 2,000 |
| Weight .. .. | 16,900 | — | 9,000 | 8,000 | 1,050 | 12,200 |
| Length, inside .. | ft. in. 19 10 | — | ft. in. 19 8½ | ft. in. 22 1 | ft. in. 5 8 | ft. in. 19 8½ |
| Width, inside .. | 5 5 | — | 5 3 | 5 3 | 4 8 | 5 0½ |
| Height, inside .. | 5 8 | — | 2 0 | 5 7 | — | — |
| Length, over coupler | 24 1½ | — | 24 1½ | 24 1½ | 6 9 | 24 1½ |
| Width overall .. | 6 6½ | — | 5 7 | 5 7 | 4 8½ | 5 7 |
| Height overall, from rail .. .. | 8 4½ | — | 4 4½ | — | 4 5 | — |
| Height to floor .. | 2 4½ | — | 2 4½ | 2 4½ | — | 2 4½ |
| Height of coupler .. | 0 17 | — | 0 17 | 0 17 | 0 17 | 0 17 |
| Wheel base, truck .. | 0 3 | — | 0 3 | 0 3 | 0 24 | 0 3 |
| Distance, C. to G. trucks .. .. | 15 0 | — | 15 0 | 15 0 | — | 15 0 |
| Diameter of wheels | 0 15½ | — | 0 15½ | 0 15½ | 0 14 | 0 15½ |

TABLE II.—*A. E. F. Light Railway Steam Locomotive.*

| | |
|---|---|
| Type .. .. .. .. .. | 2-6-2. |
| Gauge .. .. .. .. .. | 23⅝ in. (60 cm.). |
| Working pressure .. .. .. | 178 lb. per sq. in. |
| Curve, minimum radius .. .. | 65 ft. 7⅞ in. (20 m.). |
| Driving wheel base .. .. .. | 5 ft. 10 in. |
| Total wheel base .. .. .. | 15 ft. 7 in. |
| Length between couplers .. .. | 21 ft. 7 in. |
| Height of coupler, rail to centre line .. | 16½ in. |
| Width, maximum .. .. .. | 6 ft. 5 in. |
| Height, maximum above rail .. | 9 ft. 3 in. |
| Weight on drive wheels .. .. | 23,500 lb. |
| Weight on front truck .. .. | 5,000 lb. |
| Weight on rear truck .. .. .. | 5,500 lb. |
| Total .. .. .. | 34,500 lb. |
| Tractive effort .. .. .. .. | 6,225 lb. |
| Ratio of adhesion .. .. .. | 3·7. |
| Coal capacity .. .. .. .. | 1,700 lb. |
| Water capacity .. .. .. .. | 490 gallons. |

TABLE III.—*A. E. F. Light Railway Gas Locomotive.*

| | |
|---|---|
| Type—four-wheeled, four-cylinder, 4-cycle, vertical, water-cooled. | |
| Gauge .. .. .. .. .. | 23⅝ in. (60 cm.). |
| Wheel base .. .. .. .. .. | 4 ft. |
| Horse-power .. .. .. .. .. | 50. |
| Fuel capacity .. .. .. .. .. | 30 gallons. |
| Length over all .. .. .. .. | 13 ft. |
| Width overall .. .. .. .. .. | 5 ft. 2 in. |
| Height overall .. .. .. .. .. | 8 ft. 5 in. |
| Height of coupler, rail to centre line .. | 16 in. |
| Weight, total .. .. .. .. .. | 14,000 lb. |
| Transmission .. .. .. .. .. | 2 sets of speed change gears. |
| Draw-bar pull (level track) .. .. | Low gear, 3,000 lb. High gear, 1,500 lb. |
| Speed .. .. .. .. .. .. | Low gear, 4 m.p.h. High gear, 8 m.p.h. |
| Brakes .. .. .. .. .. .. | Hand brakes to all drivers. |

# THE LIGHT RAILWAYS OF THE BATTLE FRONT IN FRANCE.

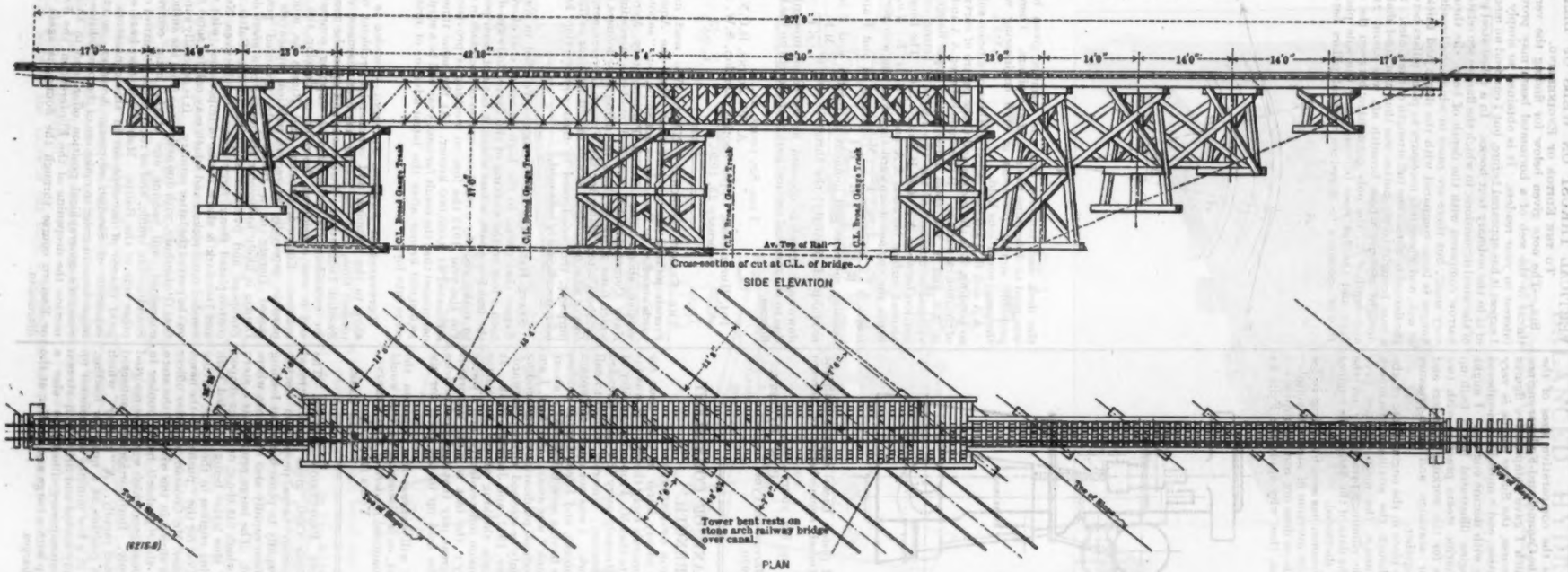



FIG. 3. BRIDGE CROSSING MAIN LINE OF THE CHEMIN DE FER DE L'EST AT SORCY.

kept in reserve, the details for which are shown in Fig. 2, on page 278.

At Sorcy, it was necessary to cross the main line of the Chemin de Fer de l'Est, and as it was near the junction of the line from Gondrecourt with the main line, four main line tracks were crossed (see Fig. 3 above). The railways at this place crossed over the canal, and the 60-cm. line was located to cross the standard-gauge tracks and canal at the same place. Fortunately, this crossing occurred in a cut, so that the line could be carried across with the minimum of bridging.

No girders or spans were available for this crossing, and it was necessary to design and build a bridge with the available material. It was found that two deck Howe trusses, with a few bents of trestle approach, would fit the conditions, give the necessary clearances, and would be the most practicable type of structure. These trusses were built of 5-in. by 10-in. road plank, and each truss weighed about 4½ tons. There was a locomotive crane working in the yard, which could lift 5 tons, so that after the bents were erected, the trusses were picked up by the crane and set in place in a few minutes. The whole bridge was framed and erected in five days, with no interference or delay to the traffic on the standard-gauge lines.

The Meuse River was also crossed by this line. At the place of crossing the stream was 125 ft. wide, with 14 ft. of water, and had very little current. Pile trestles were used in this case.

The main line of the Chemin de Fer de l'Est was crossed in the Meuse River bottom through an overflow relief opening. This structure is a good example of the splendid, beautiful masonry structures which one sees everywhere on the French railways.

Particulars of the engines and cars used on these railways are given in Tables I, II and III on the opposite page. The Baldwin engine would handle 60 tons of freight up a 3 per cent. grade. The steam locomotives were not used up to the point where their smoke and steam would betray their presence to the enemy; some little distance back from the front lines they would be cut off, and the cars were handled to the extreme front by gas engine. The operating rules were extremely simple, and dispatching was done by telephone.

## LUBRICATION.

TO THE EDITOR OF ENGINEERING.

SIR,—In the issue of ENGINEERING of February 6, an account is published of our paper on "Lubrication" recently given before the Society of Chemical Industry, and there are one or two criticisms therein to which we beg the favour of your space to make a reply.

In the first place we should like to point out that the expression "oiliness" was first used to indicate the superior lubricating properties of the fixed oils and fats over straight mineral oils under certain conditions, and we have been able to show by "direct frictional measurements" that this superiority is primarily due to the presence of small quantities of free fatty acids in the animal and vegetable oils. In this sense the explanation of "oiliness" may be said to be considerably beyond the "germ" stage—in fact, it is fully "bloomed."

Nevertheless, whatever may be said of our contributions to the "theory of lubrication," we wish to emphasize the definite *fact* that we have discovered that the addition of a very small amount of free fatty acids to mineral oils produces a lubricant possessing friction-reducing properties equal to any previously-known compound oil containing very large amounts of the expensive fatty oils.

With regard to the statement contained in the last paragraph of your article, some misapprehension appears to have arisen. We did not state that "the unsaturated compounds of mineral oils play a part akin to the fatty acids." On the contrary we have never observed this. What we did say was that the unsaturated compounds of mineral oils are a prime cause of their high viscosity, but if the question of the relation between unsaturation and oiliness is raised it should be pointed out that many of the mineral oils contain as many unsaturated linkages as do animal and vegetable oils, and yet such mineral oils are not so "oily"!

Yours faithfully,
HENRY M. WELLS.
JAMES ED. SOUTHCOMBE.

11, Haymarket, London, S.W. 1,
February 19, 1920.

[We criticised the designation "germ process" and the general, wide claims as to theory, and we do not see any reason for modifying the view we expressed as regards the discovery of the *fact*, we gave Messrs. Wells and Southcombe full credit; we emphasised the technical importance of this fact, and we did not mention that anticipation of its discovery was suggested during the discussion. With respect to the third point, Mr. Southcombe seemed, in his oral statement, to go beyond his paper; we regret that we misunderstood him.—ED. E.]

## COAL WASTAGE AND AIR POLLUTION.

TO THE EDITOR OF ENGINEERING.

SIR,—Since the opening of Parliament a fortnight ago national economy and the coal industry has received a good deal of attention, but although the Premier in one of his trite expressions said "Coal is the life blood of our industry," not one word has been said about increased economy in the use of coal.

There is to-day a universal growl about the high cost of living, and yet we all know the above expression of Mr. Lloyd George's is a fact, but still the householder in this country continues wasting from 12,000,000 tons to 15,000,000 tons of coal per year, and our various industries from 30,000,000 tons to 40,000,000 tons, simply because we neglect the elementary laws of combustion. We give too much air per pound of coal, allow the fires to burn too low before adding fresh fuel, and then dump on so much coal that the temperature of the fire is reduced below the gas ignition point, and smoke is produced.

By united action 50,000,000 tons of coal can be saved per year without interfering with either home comfort or the output of our works, and if this coal was exported it would bring into the country about 150,000,000*l.* worth of material and food-stuffs required by us, resulting in a downward tendency in the cost of living. It is nothing less than sheer nonsense to blame the Government for present conditions, which we have brought about and continue to maintain by our own selfish and extravagant use of coal.

We have our coalfields in trust for coming generations; are we honouring that trust? No, our position as a rule is that of the dishonest executor who uses his wards' money for his own extravagant tastes and leaves them penniless. That the Government is quite alive to existing conditions is evident by the mention in the news columns on Saturday last that a committee of scientists have been appointed by Dr. Addison to consider the present state of the law with regard to the pollution of the air by smoke and other noxious vapours.

It is therefore due to our wasteful habits that the Minister of Health has called the committee above referred to into being, as we certainly have no right to foul the atmosphere through our carelessness with the products of imperfect combustion throwing, as during a black smoke period, 10 per cent. of the coal placed on the fires into the air.

If coal was properly used, we could export 50,000,000 tons more per year, have cheaper food and clothing, remove to a minimum the groundwork of winter fogs with their train of inconveniences, reduce municipal

and private expenses, have richer vegetation, more sunlight, and give a purer atmosphere for all to breathe and thereby very materially reduce our death rates from tuberculosis, &c. In order to bring about these conditions we have merely to practice a little judgment as to how to use our coal, and surely this is no great hardship, especially as the coal user will be the gainer.

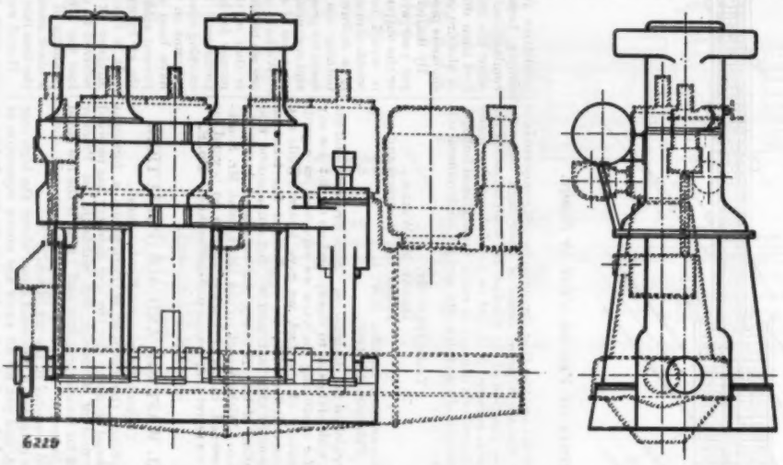
Yours faithfully,
W. H. CASMEY.

Milnthorpe, Wakefield, February 23, 1920.

## THE CAMMELLAIRD-FULLAGAR DIESEL ENGINE.

TO THE EDITOR OF ENGINEERING.

SIR,—Replying to Mr. Shannon's letter of the 17th inst., in referring to piston cooling I had in mind the upper cylinders. The gear appears to be of the telescopic pipe type, which will sooner or later leak; the flat sliding surfaces of the slipper guide, on which there is no reversal of pressure, will require ample lubrication; these features together with the scavenge pump, all immediately above the open end of an inverted cylinder, do not in my opinion constitute a desirable arrangement for a marine engine.




I would also point out that these upper guides work under worse conditions of loading than the main guides, even allowing for the decreased obliquity of the diagonal rods, as scaled from drawing, and every seagoing engineer knows what trouble a flat guide can give even in the very accessible orthodox position. The upper pistons I believe are cooled by oil in the present design, but with suitable oil standing at over 100*l.* per ton shipowners are not likely to view this with favour, when the normal engine design can quite safely use sea water for this purpose. Sea water leaking from the upper piston gear would be most undesirable.

Surely the lubricating oil consumed in lubricating the pistons depends on the number as well as the size, and taking number and size together the Cammellaird-Fullagar is about 70 per cent. greater than the normal design, which figure might be reduced to 50 per cent. if piston speed is allowed for.

Mr. Shannon has perverted my remarks *re* scavenging. I did not make the sweeping remark that one-sided port scavenging is superior to opposed piston type, although I am not prepared to admit that, when correctly designed, there is much difference in the results obtained.

I said that the Cammellaird-Fullagar engine was inferior to the valve-controlled port scavenging type, in that it could not supercharge, and I repeat that the engine, as shown in your paper, would require re-designing to arrange for supercharging.

However, the function of the cylinder is to generate power, and assuming sufficient fuel, then the power depends chiefly on the weight of fresh air present, and only to a negligible degree to the presence of a small proportion of exhaust gases, and with an efficient design of valve-controlled port scavenging system, with very little additional power for the scavenge pump, as much fresh air can be put into the cylinder as in the case of the opposed piston design, and further, the amount can be augmented without the addition of extra gear.

The opposed piston three-crank type engine can easily be arranged for supercharging by adjusting angles between the centre and outside cranks, but if this is done in the case of the Cammellaird-Fullagar engine, the scavenge and exhaust ports will require to be at opposite ends of adjacent cylinders adding further complications; this would interfere with the good balance, besides making the engine non-reversible.

As regards piston speed, my letter distinctly referred to marine engine, and the "functional reason" why the piston speed of the 1,000-h.p. Cammellaird-Fullagar engine could not be increased to 600 ft. per minute is that its revolutions per minute are already quite high enough for a good propeller, considering the type and speed of the vessel in which the engine will be fitted. The "constructional reason" is, that if the 600 ft. per minute is obtained by lengthening the stroke, the engine would be about 24 ft. 6 in. high, *i.e.*, about 15 per cent. higher than the present 1,000-h.p. Cammellaird-Fullagar engine shown on the appended sketch.

This sketch illustrates the comparative sizes of the single-acting Sulzer and the Cammellaird-Fullagar engines of equal powers, for which I gave comparative figures in my last letter. Of course, the Sulzer engine is very much simpler in construction, and it must be remembered that we are only dealing with marine engines. I might add that the Sulzer engine illustrated has a built-up crankshaft similar to marine steam practice with two interchangeable portions for the working cylinders and a separate portion for scavenge and high-pressure compressors all bolted together.

The date on the name plate in the engine-room on the Fritz is 1914, and although the auxiliary machinery showed little sign of usage, the main engines gave evidence of considerable running, presumably on the test bed, but whatever the date of the design, the engines could easily have been shortened.

I am sorry that Mr. Shannon has seen fit to drag in his last sentence, as surely the question of the most suitable engine for marine propulsion does not rest on a question of nationality; if it does, then why apply the Fullagar principle to an opposed piston Diesel engine, both the opposed piston and Diesel cycle being of foreign origin.

I am, Sir, yours truly,
P. N. EVERETT.

29, Bede Burn-road, Jarrow-on-Tyne,
February 23, 1920.

## "THE AEROPLANE OF CONSISTENT STRENGTH."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to my letter in your issue for February 6, and Mr. Pippard's reply thereto: It was far from my wish to insinuate that Mr. Pippard was guilty of plagiarism, and I am extremely sorry if I have offended him by giving that impression; I merely wished to call attention to my own work. I was not aware of Captain Green's paper on the subject, and I fear I must confess that I do not remember having seen C.I.M. 732; about the date mentioned I think I was away. Anyhow, I am pretty sure there was no official publication recommending that aeroplanes should only be stressed with c.p. forward, issued between December, 1917, and January, 1919. It seems that several people thinking about the matter came to the same conclusion independently, and I waive all claims to originality; the fact is more important than priority. It is a great pity that technical articles of this nature should be held up in the press for six months.

I hope Mr. Pippard will express his views on the technical points I raised, as a discussion on this would be profitable to all aeronautical readers of ENGINEERING.

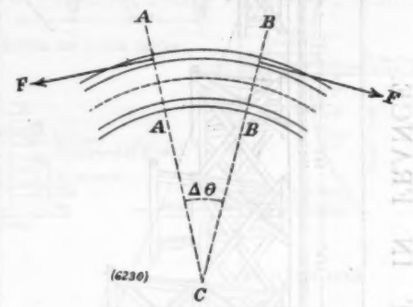
Yours faithfully,
JOHN CASE.

THE CONSTAN BARGE PROPULSION DEVICE.—The French journal, *Le Génie Civil*, gives an illustrated description of the Constan barge propulsion device, the object of which is rapidly to place barges at loading quays and to convey them rapidly also at points where they are to be unloaded. The barge proper has a stern cut out < -shaped, in which fits the < or wedge-shaped stem of the "pusher," this latter being provided with a boiler and reciprocating engines in the wings, driving two screw propellers. Coal for the "pusher"—the name given to it by the designer, Mr. Constan, a former officer in the French Navy—is stored in the wings of the stern of the barges proper; the "pusher" has a bunker in front of the boiler, the coal from which would be resorted to in exceptional cases only. Both portions are connected together and disconnected rapidly. A "pusher" which has brought a barge in position at a quay for loading, can disconnect from it in a few minutes and connect up with one which is already loaded and drive it up stream for delivery. Our contemporary illustrates also a "pusher" connected up with a barge and hauling at the same time two other barges.

## VERTICAL THRUST ON WEBS OF BEAMS.

TO THE EDITOR OF ENGINEERING.

SIR,—The note given below for finding the vertical thrust in the web of a horizontal beam may prove of interest to your readers. It is obtained so simply that I expect it has appeared before, but I can find no mention of it in the ordinary text books. In a rolled steel girder of the usual dimensions, in which the flanges are relatively narrow compared with the depth of beam the thrust is very small, but there are cases in which the breadth of flanges is large compared with the depth and thickness of web, and where it is necessary to place pillars between the flanges to obtain the full strength of the girder. Such a case brought to my notice was that of a steel shallow-draught steamer whose breadth aft was about 24 ft., and depth 6 ft., the only connection between the steel deck and the flat steel bottom being the side plating. It was necessary to introduce vertical pillars between




the deck and bottom, and the formula given below was used to determine the size of the pillars. There are probably similar problems in civil engineering where the same conditions hold.

A A and B B are two radial sections of a beam subject to bending, R is the radius and C the centre of curvature of the neutral surface. If the angle between A A and B B is $\Delta\theta$ and F the total force in the upper flange, the vertical component of the two forces F acting on the portion between A A and B B is $F \cdot \Delta\theta$. The length of neutral surface between A A and B B is $R \cdot \Delta\theta$, and hence the vertical downward thrust in the web *per unit length* is $\frac{F}{R}$, or, since $\frac{I}{R} = \frac{M}{E\,I}$ (where M and I are the bending moment and moment of inertia, and E is the modulus of elasticity) the thrust is also $= \frac{M\,F}{E\,I}$. This downward thrust is opposed by an equal upward one due to the resolved vertical part of the forces on the lower flanges.

I am, Sir, yours, &c.,
A. W. JOHNS, R.C.N.C.

104, Huron-road, Upper Tooting, London, S.W. 17.
February 23, 1920.

THE FRENCH MERCHANT NAVY.—We read in the French journal *La Journée* that what the American yards supplied to France was not ships, but "sabots"—wooden shoes. The French Parliamentary Merchant Navy Committee has received evidence according to which none of the 82 ships, including 40 schooners, built by the United States for the French Government, at a cost of 80,000,000 dols., is now in a fit state for navigation purposes, the wood used in their construction having been insufficiently seasoned.

STATE RAILWAYS OF SWEDEN.—We read in *Swedish Export* that owing to the high prices of coal there has been a loss on the working of the State Railways during the last few years, a loss which it has not been possible to make good by a rapid succession of increases in rates. For the year 1919 the loss on working is provisionally estimated at 8,000,000 kroner. At the same time it is calculated that the result for next year will be a surplus of 10,000,000 kroner after the latest advance of rates has come into force.

EXTENSION OF SWEDISH SHIPPING.—Sweden is fully alive to the shipping and commercial problems of the present time, and the matter has been discussed in the Swedish Legislature. Stress was laid upon the necessity for extending the international shipping connections, and it was considered desirable to develop the route between England, Sweden and Russia as much as possible, especially as recent political upheavals have placed Danzig in a particularly favoured position. Danzig is likely to become the centre of a great deal of European and overseas shipping to the Baltic. The contemplated steam ferry connection between Norway and Denmark is also a factor of importance, with which Sweden must reckon and which may call for some action on the part of the latter country. It is generally supposed that Gothenburg, with due assistance from the authorities concerned, will become one of the main centres for Scandinavian traffic, and as regards the countries on the other side of the Baltic. Malmö will also have a very good chance of development in this connection. The extension of Swedish shipping, however, is of first importance in order to make use of the possibilities which Sweden's geographical position offer, and in this connection the deepening of the Flinterenden, the Swedish or Eastern course through the Sound, is again under discussion.

# BALANCED HYDRAULIC VALVE.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, ERITH.

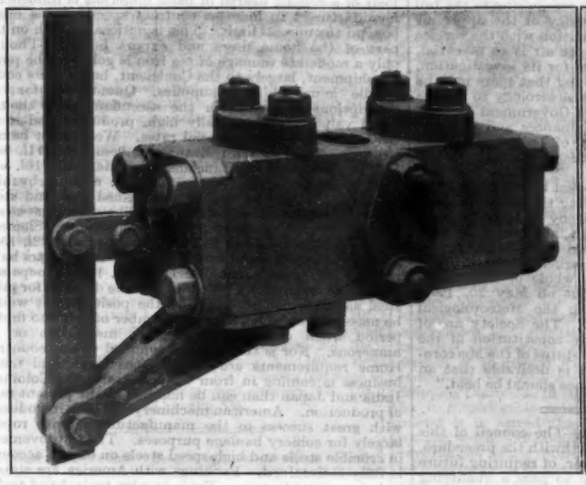


FIG. 1

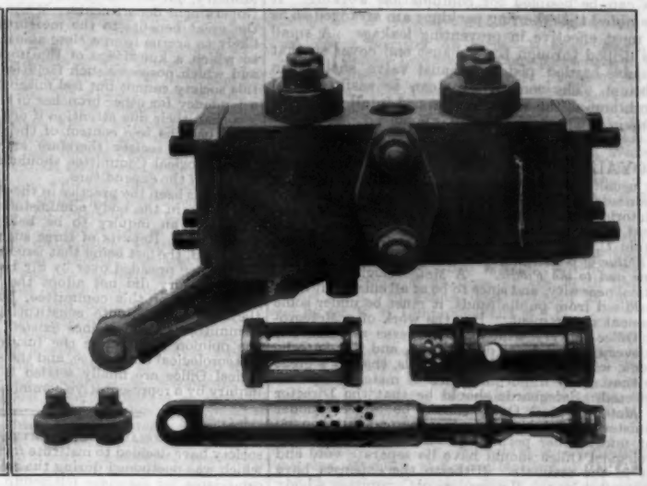
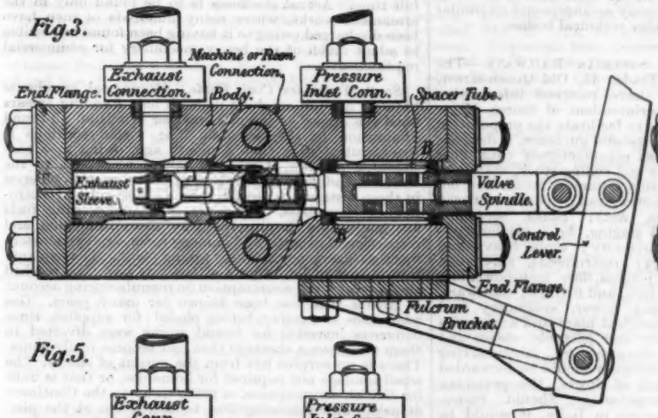
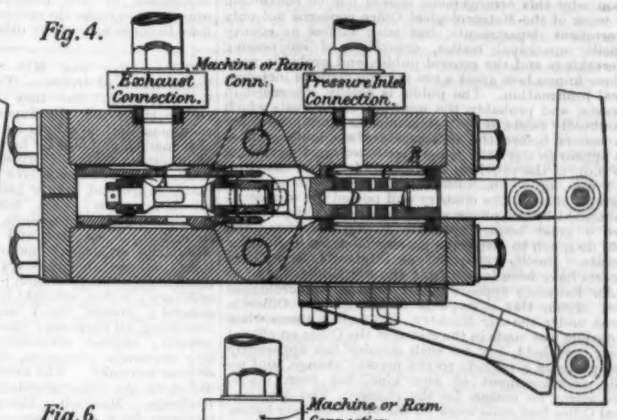
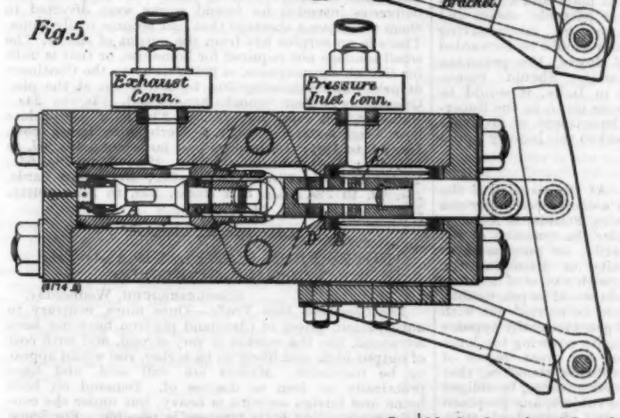
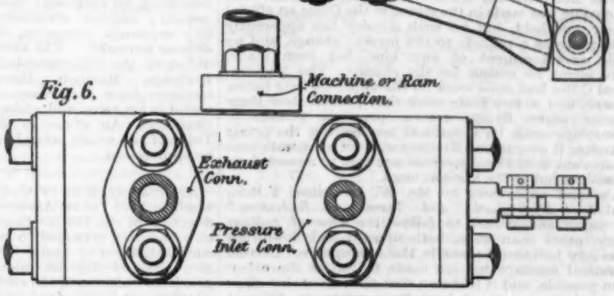


FIG. 2.




As a result of experience during the recent war in connection with hydraulic recoil and recuperator gear for gun carriages, in which finally construction and design reached a stage when hydraulic pressure could be maintained in a group of cylinders for several weeks at a stretch with a loss of less than 5 lb. pressure, Mr. Pearson, of the Erith works of Messrs. Vickers Limited, has designed the hydraulic valve which we illustrate in Figs. 1 to 6, annexed. In Fig. 1 is shown a general view of the valve, while Fig. 2 is another view with the control lever dismantled, and showing also the interior components, and links for the lever. Sections of the valve showing three working positions are given in Figs. 3 to 5, while Fig. 6 illustrates the pipe-flange connections.

The chief points about this valve are that it has been designed to eliminate leakage at the moving parts, and that it is balanced both at the inlet and exhaust ends. Ease of effecting inspections or renewals has been also a main consideration.

The body of the valve is cut from a rectangular block of steel and bored out to take the valve bushes which are shown in Fig. 2; inside these bushes works the valve itself. In Fig. 3 the valve is shown with the connection from the machine in communication with the exhaust. In Fig. 4 the position of the valve cuts off the machine both from the pressure inlet and exhaust, maintaining therefore pressure on the machine and keeping it stationary. In Fig. 5 the valve is shown putting the machine connection in communication with the pressure inlet. It will be noticed that the inlet valve is tubular, and constructed with two series of ports, C and D (Figs. 4 and 5). The pressure inlet connects with the space surrounding this valve, and when in the position shown in Fig. 5 the pressure supply is put through to the machine by way of these ports, the set C acting as inlets and D as outlets to the machine connection. At the exhaust end the ports are in the bushing, and not the valve. In the position, Fig. 5, with the supply and machine coupled up, the exhaust valve head is beyond the exhaust ports in the bush, and the exhaust is cut off. In Fig. 3, showing the machine in connection with the exhaust, the valve head is near the open end of the bush, and the ports of the latter are uncovered, allowing connection via the interior of the sleeve, to the exhaust pipe. In Fig. 4, both connections from the inlet and to the exhaust are blocked. The pressure valve works in a chamber fitted with hydraulic rubber cup packings held apart by a bulb-headed spacing tube or frame, the sides of which are cut away as shown in Fig. 2. The exhaust sleeve is held in place and packed also with hydraulic rubber. The exhaust valve heads are fitted with rubber packings pressed down on to bulb-headed rings. The rubbers used in this valve are of a special composition, which thoroughly proved its great durability and efficiency in connection with gun carriages throughout the war. They are far superior to the ordinary leathers used in connection with hydraulic installations. The pressure packings and frame, and the exhaust sleeve and packings are held in place by their respective covers, which are fastened to the body by four studs and nuts. It will thus be seen that all parts may be

quickly removed for cleaning and inspection; in fact, this can be accomplished and the parts replaced in less than 5 minutes, or in about 10 minutes if new rubbers are required. The pipe connections can be bored and fitted to different sides as convenient and two or more valves can be coupled for combination working. It will be noted that the ring packings are arranged so as to be most effective in preventing leakage. A small hole is drilled through the exhaust end cover so that the double-headed piston exhaust valve shall be in equilibrium. The control lever can be easily moved by hand, and as the valve is balanced in all positions, will remain in whatever position it is placed.

## ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 18th inst., at the Society's Rooms, 70, Victoria-street, Westminster, Mr. R. H. Hooker, president, in the chair.

Captain C. J. P. Cave brought forward a paper on "*The Status of a Meteorological Office and its Relation to the State and to the Public.*" A Meteorological Office is a practical necessity, and since to be at all efficient it must be subsidised from public funds, it must be under some Government department. But the work of a Meteorological Office is very wide, and concerns not one but almost every Government department, and if it is to be under one, without adequate safeguards, there is a great danger that many important sides of meteorology will be neglected. Safeguards should be that the Director of the Meteorological Office should be directly under the Minister of the department concerned, and on no account under other permanent officials, and that the Meteorological Office should have its separate vote and account in the estimate. Hitherto the expenses have been controlled by the Meteorological Committee, a body on which several Government departments as well as the Royal Society were represented; there seems to be no reason why this arrangement should not be continued. The work of the Meteorological Office concerns not only Government departments, but such bodies as county councils, municipal bodies, organisers of engineering undertakings and the general public, and probably none of these knows how great a use may be made of meteorological information. The public is chiefly concerned in forecasts, and probably the mistrust of forecasts which undoubtedly exists in the public mind is due to the delay that occurs before the forecasts are available. Those that appear in the daily papers are based on observations at 6 p.m. of the previous day, but if forecasts based on the 1 a.m. or 7 a.m. observations were sent to every telegraph office in the country and posted up, and could be obtained by telephone subscribers, it would probably prove a great boon, especially to agriculturists, and would do much to dispel the present mistrust of weather forecasts. During the past year Meteorological Office forecasts have been issued from the Air Ministry, and in the Air Estimate appears a sum for the Meteorological Office. From this it appears as though the Office is to pass under the Air Ministry. In former times when any change was made in the status of the Office an official inquiry was held, but no such inquiry has apparently taken place as a prelude to the present change, and no public announcement of any kind has been made. There seems no reason for the change. The Meteorological Office had done work on the upper air long before the war, and it was their work that proved that long-distance night flying was a practical possibility. Meteorology must be a national service, but the policy of handing it over to one Ministry without a separate vote and account would be disastrous not only to meteorology as a science but to the State at large.

A second paper was by Mr. W. H. Dines, F.R.S., entitled "*Atmospheric and Terrestrial Radiation.*" The paper endeavours to follow the flow of radiant energy, other than solar, both upward and downward across any horizontal plane in the atmosphere. Certain theoretical assumptions are made to render the calculation possible, and it is shown that the curves that show the net loss or gain of heat from strata at different heights are all more or less of the same character, whatever possible values are ascribed to the emissivity of the various strata. It is found that over Europe the air from the earth's surface up to about 8 km. is losing heat by radiation; that from 8 km. to 12 km. it is gaining heat, and losing it again over 12 km. The validity of the assumptions made is then discussed, and it is pointed out that the numerical values obtained agree well with those obtained by entirely different means.

Mr. D. Brunt, M.A., also read a paper on "*Internal Friction in the Atmosphere.*" When a steady state of motion is assumed, any portion of the atmosphere is in equilibrium under the action of three forces, the gradient of pressure, the deflecting force at right angles to its motion, and the frictional force. The first two of these are measurable and so the third can be evaluated. The paper gives a comparison of the frictional force calculated in this manner with the values derived from a theoretical discussion of turbulent motion. A new derivation of the solution of the equations of motion is given. Use is made of observations made at the top and base of the Eiffel Tower, to derive the value of the coefficient of eddy viscosity. An additional note shows that a solution of the equation of motion is possible in cases where the coefficient of eddy conductivity varies with height.

The following resolution was adopted at the meeting:—"The Royal Meteorological Society observe that in the Air Estimates for 1919-20 published last December there appears a sum of 12,000*l.* as a supplement to the grant in aid of the Meteorological Office. It would appear from this that it is intended that the finances of the Meteorological Office shall pass under the control of the Air Ministry.

"The Meteorological Office deals with a variety of problems of high scientific and practical importance, some of which have no bearings on the work of the Air Ministry, but are closely connected with the work of other Government departments. While recognising to the full the great benefits to the meteorology of the upper air likely to accrue from a close association with the service to which a knowledge of the upper air is so essential, and which possesses such facilities for its investigation, this society cannot but feel misgiving that there may be a tendency for other branches of meteorology to receive less than their due attention if one Government Department has the sole control of the finances and management. The society therefore are of opinion that the Meteorological Committee should continue to have full control of the expenditure.

"It has been the practice in the past before any change was made in the body administering the Meteorological Office for an inquiry to be held by a Departmental Committee. Reports of three such inquiries have been published, the last being that issued in 1904 of a Treasury Committee presided over by Sir Herbert Maxwell, Bart. The Treasury did not adopt the whole of the recommendations of this committee, but on May 20, 1905, they issued a minute constituting the Meteorological Committee as it has since existed. The Society are of the opinion that before the future constitution of the Meteorological Committee, and the status of the Meteorological Office are finally settled it is desirable that an inquiry by a representative committee should be held."

ROYAL AERONAUTICAL SOCIETY.—The council of this society have decided to institute forthwith the procedure, which was postponed during the war, of requiring future candidates for associate fellowship to pass a qualifying examination in the science of aeronautics, or to produce evidence of having passed some equivalent examination recognised by the council. A committee is being appointed to make the necessary arrangements on similar lines to those adopted by other technical bodies.

CATALOGUES FOR MESOPOTAMIAN RAILWAYS.—The Department of Overseas Trade, 35, Old Queen-street, S.W. 1, state that they have received information to the effect that the Superintendent of Stores, Mesopotamian Railways, in order to facilitate the preparation of demands, and also for his general guidance, is desirous of obtaining copies of British manufacturers' catalogues dealing with: Locomotives and rolling-stock, standard, metre-gauge and narrow gauge; pumps, steam and oil, all descriptions; cars, motor rail; permanent-way material (rails, fastenings, &c.); tanks, sectional, wrought-iron, cast-iron and staging, &c.; machinery—workshop, repair and manufactory; tools, heavy and light, as used on railways; instruments, surveying, mathematical and precision; lights, flare, high-power and ordinary; piping, wrought-iron, and fittings; hardware, general; cranes, hand and power, stationary and travelling, all purposes; electrical plant and accessories general; engines, stationary and portable, steam and oil; ropeways, conveyors, elevators, &c., labour-saving devices generally. The catalogues should be forwarded direct to the Superintendent of Stores, Mesopotamian Railways, Makinah, Mesopotamia. Should manufacturers have a representative in India, it would be useful if his name and address were given to the Superintendent. An advice to the Department of Overseas Trade of any action taken in regard to this inquiry would be appreciated.

STANDARDISATION OF GEARS.—At the request of the Machine Tool Trades Association a conference under the direction of the British Engineering Standards Association has been arranged to consider the question of the standardisation of gears. Primarily, its purpose is to give the industry an opportunity of discussing the problems which beset the subject, with a view of deciding whether standardisation in this field would be practicable, and, if so, to what extent it could be carried out with beneficial results. The subject of gears generally appears to be in itself one of great complexity covering too large a field to make it susceptible of any great degree of general standardisation. It is probable, therefore, that whilst the conference will, in the first instance, be obliged to take a brief survey of the whole subject, any proposed investigation from the point of view of standardisation will have to be narrowed down to attacking a few definite points in some particular branch of the industry. It is understood that American manufacturers are devoting considerable attention to this question, and as the British Engineering Standards Association is in close communication with the American industry, through the American Engineering Standards Committee, such a conference as is now proposed should do much to bring British manufacturers together at a most opportune time, and promote Anglo-American co-operation on what is acknowledged to be a most important subject to the industries of both countries. The conference is to be held under the direction of the Sectional Committee on Machine Parts, their Gauging and Nomenclature, on March 5, at 3.30 p.m., at the Institution of Civil Engineers, Great George-street, S.W. 1. A large number of invitations have already been issued through trade and technical associations. Any individual firm or expert, however, who has not received a communication with regard to the conference and who is directly interested in the question, is invited to communicate direct with the Secretary of the British Engineering Standards Association, 28, Victoria-street, S.W. 1.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—An outstanding feature of the market is the tremendous demand for raw and semi-finished materials. Instead of restricting trade, the imposition of higher prices has been marked by a big influx of orders. Fear of a coming dearth in basic materials is influencing manufacturers to increase contract specifications much beyond the normal limit. This is noticeable both on the part of the home users and export buyers. Though only a moderate tonnage of pig-iron is going to the ports for shipment, largely to the Continent, home users could handle much bigger supplies. Quotations for all descriptions are again in the ascendant, and though listed values are abnormally high, producers find it an easy matter to obtain special rates. West Coast hematites are offered at 12*l.*; East Coast hematites, 11*l.* 8*s.*; Lincolnshire forge and Lincolnshire basic, each, 10*l.* 5*s.*; Derbyshire forge, 10*l.* 3*s.* to 10*l.* 6*s.*; and Derbyshire foundry, 10*l.* 10*s.* to 10*l.* 15*s.* Finished iron and steel billets have advanced something like 350 per cent., compared with the last pre-war quotations. Siemens acid billets are listed at 23*l.* 5*s.*, Bessemer acid 22*l.* 15*s.*, hard basic 20*l.* 5*s.*, and soft basic 20*l.* Crown bars have reached the unprecedented level of 24*l.* 10*s.* Hoops are making as much as 29*l.* To describe the demand for mild steel as abnormal, scarcely fits the position. It would be necessary to go back a large number of years to find a period when orders were of such magnitude or so numerous. Nor is the demand confined to one country. Home requirements are on a record level, and more business is coming in from France, Italy, the Colonies, India and Japan than can be handled at the present rate of production. American machinery has been introduced with great success in the manufacture of wire ropes, largely for colliery haulage purposes. The improvement in crucible steels and high-speed steels on export account is fully maintained. Bookings with America are stated to be very satisfactory. Trade in edge tools, hand tools, gardening requisites and implement machinery parts is sufficient to keep the bulk of the local works running full time. Actual slackness is to be found only in the armament works, where many hundreds of men have been discharged owing to it having been found impossible to adapt much of the heavy machinery for commercial requirements.

*South Yorkshire Coal Trade.*—House-coal merchants have no hope of catching up with long-standing arrears until the arrival of warmer weather brings an all-round diminution in the demand. The wagon shortage is more acute to-day than a month ago, owing to a considerable number of wagons having been sent to the Durham and Northumberland areas to enable collieries in those districts to furnish relief to Midland and Metropolitan consumers. Deliveries of manufacturing fuels are inadequate despite the very close inspection and restriction of exports, and in many cases serious encroachment on emergency stocks is taking place. The explanation is that while outputs at the pits have not reached the pre-war level, consumption on manufacturing account is greater than has been known for many years. Gas companies are rather better placed for supplies, since deliveries intended for inland works were diverted to them to relieve a shortage that had become really acute. There is no surplus left from the output of slacks. The small tonnage not required for home use, or that is unfit for British consumption, is going away to the Continent at prices approximating 50*s.* to 60*s.* a ton at the pits. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 23*s.* to 24*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—Once more, contrary to anticipation, prices of Cleveland pig-iron have not been advanced, but the market is very strong, and with cost of output high, and likely to be higher, rise would appear to be inevitable. Makers are well sold, and have practically no iron to dispose of. Demand on both home and foreign account is heavy, but under the conditions prevailing little business is possible. For home consumption, No. 1 Cleveland pig-iron is 182*s.* 6*d.* and No. 3, as well as the inferior grades, is 175*s.*; and for shipment to France, Belgium and Italy, No. 1 is 187*s.* 6*d.* and No. 3 and the lower qualities are 180*s.* Very high rates are offered for iron for other countries, and the minimum price for such business is 230*s.*, but very little iron indeed is available for trade of that kind.

*Hematite Iron.*—Though East Coast hematite prices have not moved upward, current rates are declared to be unremunerative, and business is at a standstill. Makers are well placed and are not disposed to accept orders at present. Thus recognised market rates are nominal at 222*s.* 6*d.* for No. 1 and 220*s.* for mixed Nos., for home purposes; and 232*s.* 6*d.* for No. 1 and 230*s.* for mixed Nos., for export to France, Belgium and Italy.

*Foreign Ore.*—The situation as regards foreign ore is becoming more and more serious. Sellers are in a very strong position and prices are still ascending. Market rates are regarded as based on 50*s.* for rubio, of 50 per cent. quality, on the 17*s.* parity freight, Bilbao-Middlesbrough. As, however, sellers are now asking 51*s.* for ore, and steamers from Bilbao cannot be chartered under

37*s.*, whilst as much as 39*s.* is named, the c.i.f., Tees figure for best rubio has become anything between 70*s.* and 73*s.*

*Coke.*—Coke keeps strong. As yet prices are unchanged, but supplies fall vastly below requirements, and a rise may occur at any time. Local users complain greatly of insufficient deliveries. Average blast-furnace coke is 50*s.* 6*d.* at the ovens, and quality low in phosphorus is 53*s.* For export practically any description of coke commands 120*s.*

*Manufactured Iron and Steel.*—No abatement can be reported in the huge demand for finished iron and steel. Unfortunately, lack of adequate transport facilities is as pronounced as ever, and the consequent growing accumulation of stocks threaten to stop the working of some mills. Congestion at several establishments is positively alarming. Manufacturers generally are so overwhelmed with orders that they cannot undertake new business. Customers are keen to make contracts, and would readily pay even above the high rates ruling if they could be guaranteed delivery, but until a better wagon supply is provided such an assurance cannot be looked for. The deliveries of plates to the shipyards are on a far from satisfactory scale. Export quotations are higher than the following, which are the minimum rates for home trade:—Common iron bars, 24*l.*; marked bars, 26*l.*; steel ship, bridge and tank plates, 21*l.*; steel boiler plates, 24*l.*; steel angles, 20*l.* 10*s.*; steel joists, 20*l.* 10*s.*; soft steel billets, 19*l.* 10*s.*; hard billets, 20*l.* 10*s.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; heavy sections of steel rails, 19*l.* 15*s.*; fish plates and sleepers, 24*l.* 15*s.*; and galvanised corrugated sheets, 53*l.*

BRITISH STANDARD SPECIFICATIONS.—The British Engineering Standards Association has now issued specification No. 73, 1919, covering 5-ampere, 15-ampere and 30-ampere two-pin wall plugs and sockets, for domestic purposes (without earthing connection), revised December, 1919; and specification No. 98, 1919, on Goliath lamp caps and lamp holders for various currents, powers and pressures. The price of each specification is 1*s.* net. (1*s.* 2*d.* post free), and they may be obtained from the publishers, Messrs. Crosby, Lockwood and Son, 7, Stationers' Hall Court, E.C. 4.

OVERSEAS TRADE.—H.M.'s Trade Commissioner in Winnipeg states that he is of the opinion that reliable agencies should be arranged forthwith by United Kingdom manufacturers with reliable Western Canadian representatives and that such representatives would do a great deal of useful educational work until such time as deliveries can be made. A Western Canadian agent who represents a British house is proud of the fact and does not hesitate to let the trade know it. Western Canada is apparently on the threshold of a period of great expansion and development, and its requirements in manufactured goods from now on will exceed any previous record. In the matter of all products, the United Kingdom will need to make more strenuous efforts than heretofore to obtain a substantial share of Western Canada's trade, and this applies particularly to all metal products and machinery.

POWER CHARACTERISTICS OF FUELS FOR AIRCRAFT ENGINES.—The importance of securing the best possible fuel for aircraft engines led to the testing of 12 different gasolines in an aviation engine in the altitude chamber of the American Bureau of Standards dynamometer laboratory. During the tests the engine was operated under conditions simulating those encountered in flight at altitudes up to 30,000 ft. The results of the tests are contained in the Report No. 47 of the National Advisory Committee for Aeronautics, Washington, D.C. They indicate no differences in excess of 5 per cent. in the maximum power developed by each gasoline when carburation is adjusted to each fuel. The question of economy is not considered in the report. Several physical properties of the fuels, including the distillation temperatures, were compared in an effort to identify those controlling the power-producing capacity, but no correlation was disclosed. A copy of the said report may be obtained on application to the National Advisory Committee.

PERSONAL.—The Paterson Engineering Company, Limited, 11, Southampton-row, W.C. 1, state that they have now opened their own office at Temple Chambers, Calcutta, for the handling of water purification and water works engineering contracts in India and the Far East. Mr. J. E. Walker, M.I.Mech.E., has been appointed their general manager in India.—Messrs. Drake and Gorham, Limited, announce that as from March 1, their head office will be removed from 66, Victoria-street, where they have been established since 1886, to 36, Grosvenor Gardens, Westminster, S.W. 1. Their telegraphic address will be "Accumulator, Sowest, London," and telephone Nos. Victoria 9060 (5 lines). Their stores remain at 67, Long Acre, W.C. 2, and their works remain the Rockingham Works, Newington Causeway, S.E.—The directors of the North-Eastern Railway Company have appointed Sir John Rumney Nicholson, C.M.G., M.I.C.E., M.I.M.E., to the position of docks engineer. Sir John Nicholson was until recently chairman and chief engineer to the Singapore Harbour Board.—As from Monday last, the 23rd inst., the address of the Department of Scientific and Industrial Research is 16 to 18, Old Queen-street, Westminster, S.W. 1. Telephone, Victoria 7940.—Messrs. Charles Churchill and Co., Limited, inform us that they have opened a new branch office at 53, Bridge-street, Sheffield.

## NOTES FROM THE SOUTH WEST.

CARDIFF, Wednesday.

*The Coal Markets.*—A sudden strike of 30,000 miners in the Rhondda on Monday, as the result of a couple of local disputes, and a diversion of large quantities of coal from export to the home market, brought business to a virtual standstill. Fortunately the Rhondda disputes were quickly settled, and a return to work made after a 24-hours' stoppage. The effects of the stoppage are, however, likely to prove serious, for the Coal Controller issued orders that practically the whole of the output of Monmouthshire, and a considerable proportion of that from the Glamorgan collieries, was to be despatched to home consumers, 50 per cent. by rail and the rest by steamer. This diversion has thrown the coal trade into a state of chaos, for special arrangements are being made by the railways to deal with the extra quantities, and the direction of British shipping to home ports has been exceedingly heavy. The orders of the Coal Controller were issued contrary to the advice of the local committee dealing with the distribution of outputs, and the secretary of this committee resigned, but afterwards withdrew his resignation, but left the responsibility for the effect of such diversions on the Coal Mines Department. Yesterday the Coal and Shipping Controllers visited Cardiff and held conferences with the various committees and officials dealing with the coal trade, and also ship owners, and a working arrangement was arrived at in regard to the distribution of coal and a committee of ship owners appointed to advise the Shipping Controller in respect to the direction of tonnage. As a considerable number of wagons has been sent inland it is feared that there is great danger to the regular working of collieries, because of the delay usually experienced in the return of trucks. Meanwhile, releases for export are very sparingly granted, and coals used for gas-making purposes have been prohibited from shipment. In the circumstances prices are nominal, as collieries have practically no coal free, and are on the basis of up to 115*s.* for large and 95*s.* for best steam smalls. Exports last week from South Wales, foreign, totalled 338,761 tons, of which about half went to France. Shipments from Cardiff totalled 186,714 tons, Newport 79,787 tons, Swansea 47,863 tons, and Port Talbot 24,397 tons. Coke is very scarce and firm up to 150*s.* and patent fuel 120*s.* Pitwood is easier round 87*s.* 6*d.*

*The Iron and Steel Trades.*—There is a relaxation in the demand both in respect to home and foreign requirements. Makers are, however, generally well booked up with orders and prices in consequence show no material alteration. Tin plates still command 71*s.* 6*d.* for the basis box, for early delivery, with about 70*s.* quoted for forward consignments. The workmen have now agreed to make an application for an advance of 50 per cent. on the present basis rate, that an additional 25 per cent. be claimed for plates on gauges 26 to 29, inclusive, and that all men on a 6-hours' shift be granted an additional 25 per cent. Steel bars are steady at 30*l.* per ton, and galvanised sheets are firm up to 52*l.* per ton for 24-gauge corrugated, in bundles, for June-July shipment.

BRITISH BUSINESS ABROAD.—One of the aims of the Department of Overseas Trade is to bring its overseas services into close personal touch with business men, and British firms when sending representatives abroad are recommended to instruct them to call on H.M. Consular Officers in the countries they visit, and on the Commercial Diplomatic Officer in the capital of each country, and in the case of the Dominions on H.M. Trade Commissioners. Commenting on this subject, H.M. Commercial Counsellor in Rome remarks "that it would certainly be in the interests of business men generally if they made a habit of calling upon him, and on the Consuls where they are transacting business. Experience has proved that while people never fail to appeal to the Consul when in need of assistance they frequently omit to call and discuss commercial matters. If a practice of doing so were made, both they and others might derive considerable advantage from business information and experience."

BUSINESS IN ARGENTINA.—H.M. Consul-General at Buenos Aires strongly urges British manufacturers and exporters who have local agencies in the Argentine Republic, to request their representatives to send a complete detailed report on the best ways and means of increasing their trade. With reference to propaganda, representatives do not as a rule carry on a continuous campaign to create a demand for their goods for the following, among other reasons: (1) It takes up a lot of time, and the major part of the cost, after the initial stage, may have to come out of their own pockets, as sufficient sums of money are not provided by the manufacturers for the purpose; (2) the representatives do not see the full force of such work and the benefit to be derived from it; (3) representatives may have insufficient staff to cope with this work. "What I mean by propaganda work is not merely putting goods before the importers and trying to secure their orders, but bringing goods before the retailers and the consumers where possible even though it would not be expedient to sell to them. Of course, I realise that the work entailed in carrying out this campaign would necessitate a considerable amount of time, but if systematically pushed forward by the representative alone or in conjunction with their customers, the principal importers, I am convinced that the results would be very far-reaching and, would in many cases, give a greater impetus to trade than is possible by advertising in periodicals, unless carried out on a very large scale." These suggestions are valuable.

## NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 27. Informal Meeting at 7 p.m. Discussion on "The Education of the Engineer," to be opened by Mr. F. W. C. Dean, M.B.E., Member.

THE ROYAL SOCIETY OF ARTS.—Monday, March 1, at 8 p.m.: Cantor Lecture, "Recent Researches in the Cellulose Industry," by Mr. Charles Frederick Cross, B.Sc., F.R.S., F.C.S. (Lecture III). Tuesday, March 2, at 4.30 p.m.: Colonial Section, "Trade Routes for the Empire in Africa," by Mr. G. F. Scott Elliot, M.A., B.Sc., F.R.G.S.; Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., will preside. Wednesday, March 3, at 4.30 p.m.: Ordinary Meeting, "Mongolia from the Commercial Point of View," by Mr. William James Garnett, First Secretary, H.B.M. Diplomatic Service.

THE SOCIETY OF ENGINEERS.—Monday, March 1, at 5.30 p.m., in the Rooms of the Geological Society, Burlington House, W., when a paper will be read on "Some Engineering Work done by the 277th Railway Company (R.E.) in France and Belgium During the War," by Mr. R. H. Cunningham, A.M.S.E.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, March 3, at Denison House, Vauxhall Bridge-road, Westminster, S.W., when a Sessional Meeting will be held. "Housing and Town Planning in Greater London," by Captain R. L. Reiss, Chairman of the Garden Cities and Town Planning Association. The president will take the chair at 8 p.m.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, March 3, at 8 p.m., Meeting at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W. 1, when Mr. P. J. Worsley will read a paper entitled "Gears and Gear Cutting."

THE ROYAL AERONAUTICAL SOCIETY.—Wednesday, March 3, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. A paper on "Flying over Clouds in Relation to Commercial Aeronautics" will be read by Professor B. Melvill Jones, Associate Fellow. The chair will be taken by Lieutenant-Colonel H. T. Tizard, Fellow.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Wednesday, March 3, at 7.30 p.m., Engineering Lecture Theatre, Liverpool University, Mr. D. H. Yates, A.M.I.M.E., on "The Una-Flow Steam Engine." Thursday, March 4, at 8 p.m., Milton Hall, Manchester, Mr. Peter Doig, on "The Screw Propeller," being an official Association Lecture. Friday, March 5, at 7.30 p.m., Applied Science Department, Sheffield University, a Local Member will read paper on "Flat Plates," by Mr. C. C. Pounder, A.M.I.M.E., this being an official Association Lecture. Friday, March 5, at 7.30 p.m., the Technical School, Barrow-in-Furness, Mr. M. Coronel, on "Gearing Design," this being an official Association Lecture.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (MANCHESTER CENTRE).—Friday, March 5, at 7 p.m., at the College of Technology, Manchester, a debate will take place on the subject "Electric Traction," to be opened by Mr. W. A. Barnes, A.M.I.E.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 5, at 9 p.m., a discourse will be delivered by the Hon. J. W. Fortescue, C.V.O., LL.D. The subject is "Military History." Afternoon Lectures, at 3 p.m.: Tuesday, March 2, Professor Arthur Keith, M.D., LL.D., F.R.S., F.R.C.S., M.R.I., on "British Ethnology: The Invaders of England" (Lecture I); Thursday, March 4, Lieutenant-Colonel Ernest Gold, R.E., D.S.O., F.R.S., on "The Upper Air: (1) Modern Methods of Investigation, and their Application in the War"; Saturday, March 6, Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., M.R.I., on "Positive Rays" (Lecture III).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 5, at 39, Victoria-street, Westminster, S.W. 1. Lecturette, "Notes on Gauge Testing and Measuring Appliances" (slides and exhibits), by Mr. F. H. Rolt, B.Sc., Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 5, at 6 p.m., Storey's Gate, St. James' Park. Adjourned discussion on the alterations of, and additions to, by-laws. Adjourned discussion on "Recent Advances in Utilisation of Water Power," by Mr. E. M. Bergstrom, of London, Associate Member.

ELECTRIC DRIVE FOR ROLLING MILL FOR LEAD SHEETS.—With reference to the article on page 215 *ante*, regarding the electrical equipment of a lead-rolling mill at Messrs. Holman, Mitchell and Co., Limited, St. Helens, it should have been stated that this work was carried out under the supervision of Mr. A. W. Wylie, consulting engineer, Johnstone, Scotland.

KING'S COLLEGE, LONDON: OLD STUDENTS' ASSOCIATION.—There is a strong movement on foot for forming a properly constituted Old Students' Association at King's College, London. A committee was lately formed which has drawn up a provisional constitution, and a general meeting has been called for March 4, at 6 p.m., at the college, in order to ratify it. It has been possible to send notices of this meeting only to those old students whose names are on the register, but it is hoped that the meeting will be made widely known, and that as many old students as possible will be there.

# 700-TON METAL MIXER AT THE NORMANDE STEEL WORKS, CAEN, FRANCE.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 293.)

FIG. 13. VIEW OF MIXER AT PLATFORM LEVEL, SHOWING SLAGGING SPOUT.

FIG. 14. VIEW OF MIXER FROM GROUND LEVEL; DISCHARGING SIDE.

# 60-TON LADLE CRANES AT THE NORMANDE STEEL WORKS, CAEN.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 293.)

Fig. 15. General View showing Ladle Cranes and Metal Mixer.

Fig. 16. View of 60-Ton Ladle Cranes over the Casting Pits.

(*To face page* 292.)

# 700-TON METAL MIXER AT THE WORKS OF THE SOCIÉTÉ NORMANDE DE MÉTALLURGIE, CAEN, FRANCE.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 293.)

*Fig. 17.*

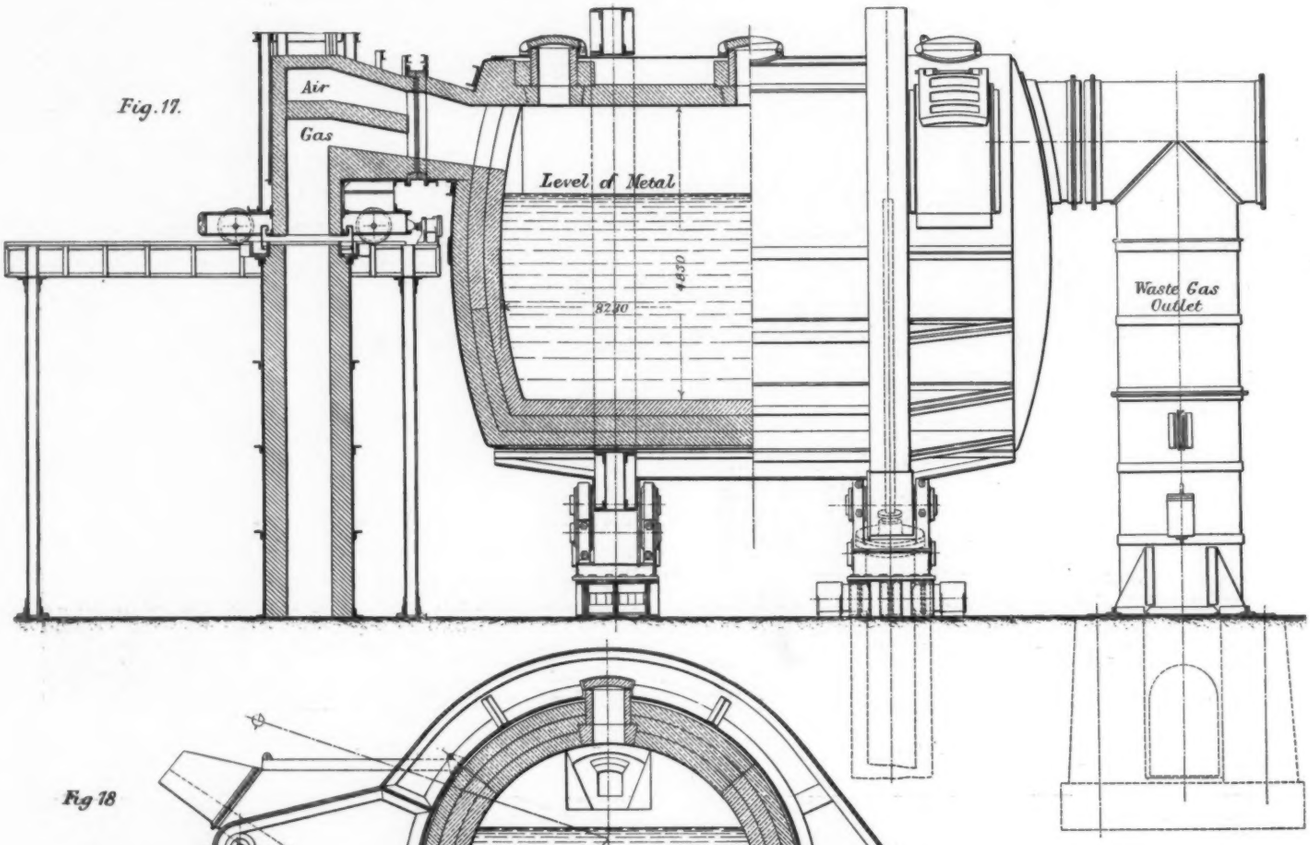



*Fig 18*

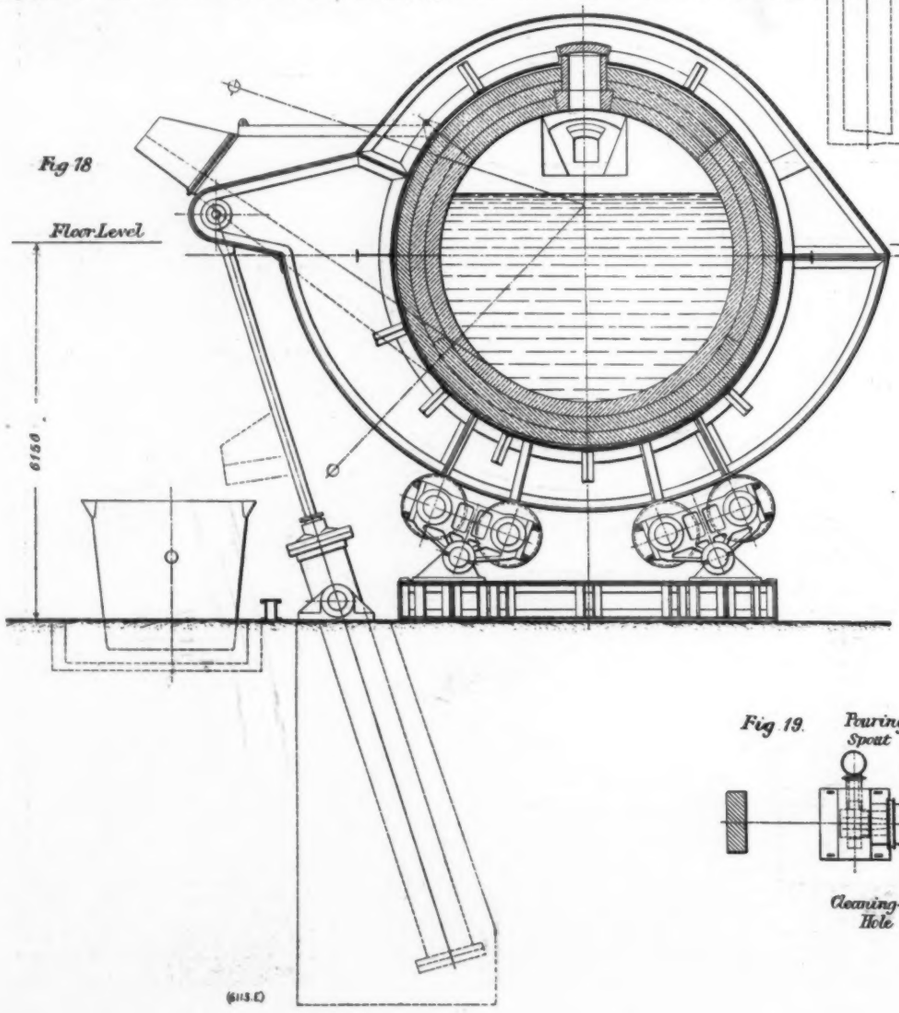
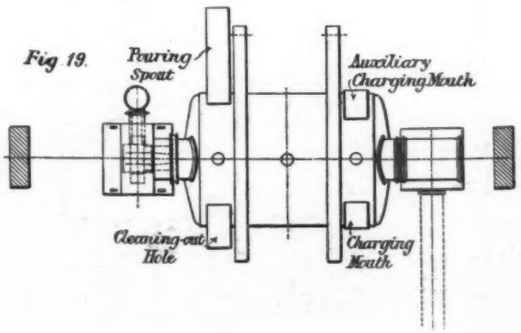



*Fig 19.*



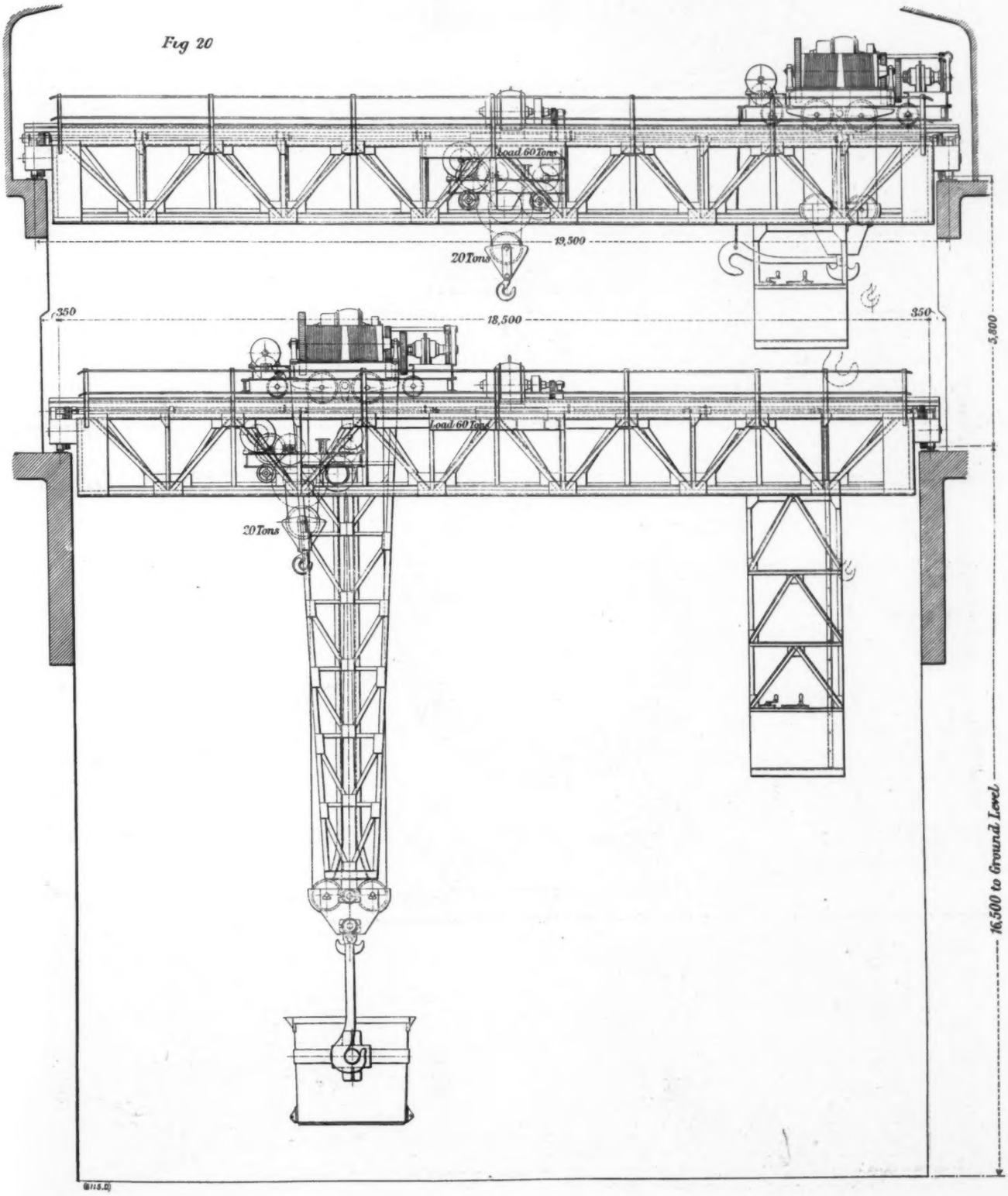

(113.D)

# 60-TON LADLE CRANES AT THE WORKS OF THE SOCIÉTÉ NORMANDE DE MÉTALLURGIE, CAEN, FRANCE.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 293.)

*Fig 20*



# SOAKING PITS AND BILLET HANDLING CRANE, NORMANDE WORKS.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 293.)

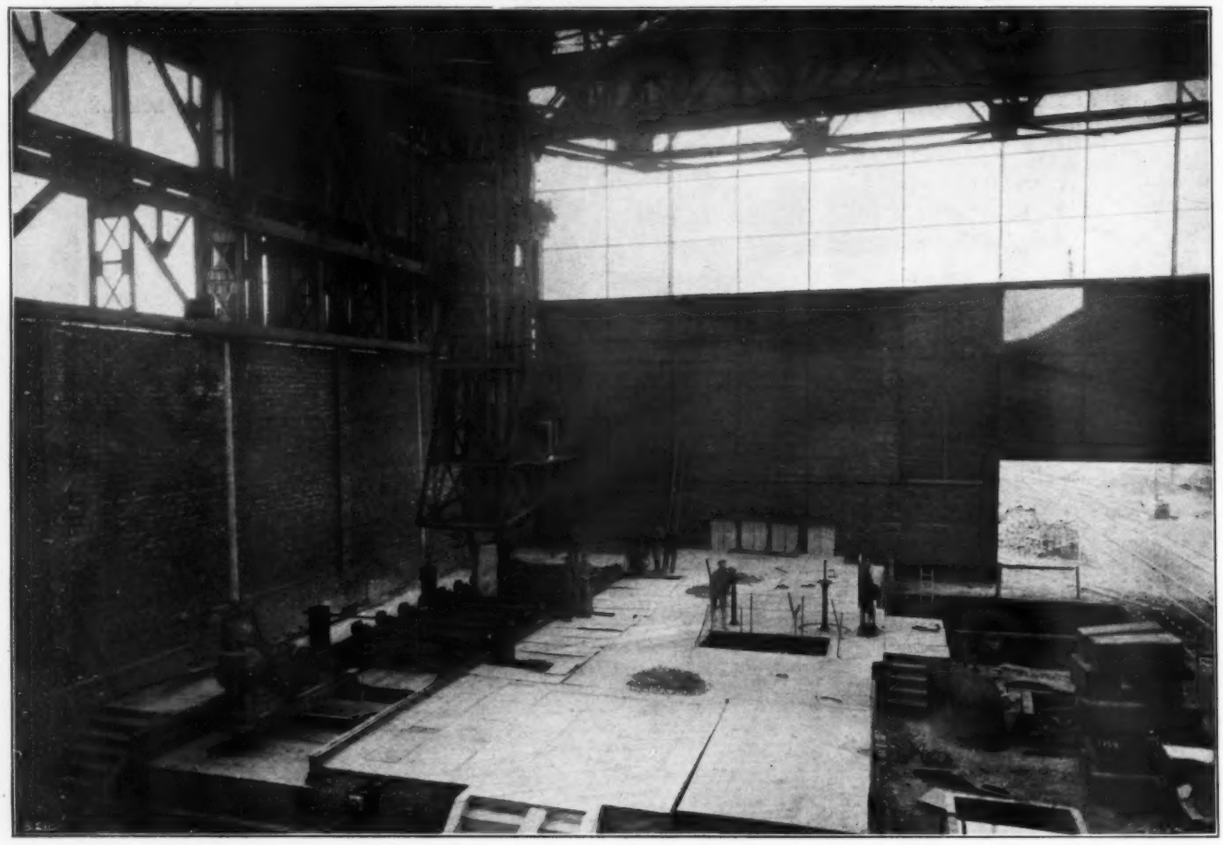


FIG. 21. VIEW OF SOAKING PITS AND COMBINED STRIPPING AND CHARGING CRANE.

FIG. 22. BILLET HANDLING CRANE.

(*To face page* 293.)

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*With Four One-Page Plates of the MACHINERY AT THE STEEL WORKS OF THE SOCIETE NORMANDE DE METALLURGIE, CAEN, FRANCE.*

## NOTICE.

**Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase dates from and includes the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.**

### NOTICE TO NON-SUBSCRIBERS.

**In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.**

### NOTICES OF MEETINGS.

**Notices of Meetings to take place during the present and next week will be found on page 283.**


# ENGINEERING.

*FRIDAY, FEBRUARY 27, 1920.*


## THE DUTY OF TRADE UNIONS TO EX-SERVICE MEN.

DEFECTIVE imagination is probably the cause of the opposition which certain trade unions have raised in connection with schemes for the training of ex-service men. We do not know if the members of the unions concerned will care for this explanation. Some people would rather be described as unpatriotic, or selfish, than as having defective imagination, and they may be among them. Be that as it will, we think the explanation is correct. Labour men are fond of contrasting the capitalist who gave his money, at not inadequate interest, with the soldier or sailor who gave some of the best years of his life, mortgaged his future and came through crippled, or perhaps permanently debilitated. The comparison may not unjustly be bourne in mind. It weakens only before the further comparison with those who

> "... laid the world away; poured out the red
> Sweet wine of youth; gave up the years to be
> Of work and joy, and that unhoped serene,
> That men call age;"

Remembering what some of our discharged service men have given up in happiness and prospects it is difficult to see how anyone can oppose a reasonable scheme for starting them in civil life again. We think, as we have said, that the opposition is due to defective imagination. The opponents have not remembered.

An emotional experience falls into the background of the mind with lapse of time. Something of intellectual and imaginative effort is necessary to carry it on. With most of us the once stark fact gradually fades in the picture and is hidden by the mist of everyday things. In many of the affairs of life this is well, but in the exceptional case it may breed grave injustice. We can but think that such Labour opposition as we have referred to must be due to this cause. This, however, is an explanation, not an excuse. Doubtless the opposition has been exaggerated as most political things are, but none the less it certainly exists. It may have a case, but it can be no case which meets the facts. The whole matter is deplorable, and we find it hard that the opposition has been seen in its worst form in connection with the skilled labour branch of the great industry with which we are connected.

In the discussion of this subject in the House of Commons on the 18th inst., Mr. Sexton stated in mitigation of the opposition of labour, that employers were not keeping open the jobs for service men which had been promised and which they had occupied before the war. Mr. Young said something of the same sort. We are not concerned for the moment with these charges. Even if they were proved we could not admit them in evidence. That two wrongs do not make a right is very elementary ethics. The other main argument—we think we may say the other main defence—which was raised was that the amount of employment in the skilled trades concerned was insufficient to justify the inclusion in them of large numbers of ex-service men who had not been concerned with them before the war. In this we meet the main cause of the opposition. It is worthy of discussion and examination, but we think the exercise of a little more imagination by the unions concerned and a little keener recollection of the services they were proposing to ignore would have outbalanced any personal calculations about employment and unemployment. For the sake of ordinary human nature we could have wished that a little risk had been taken.

Although we have indicated, as we hope very clearly, that in our opinion no argument has been advanced which excuses the refusal of certain skilled unions to agree to training schemes for ex-soldiers and sailors, we are quite prepared to admit that the unemployment argument of necessity carries great weight with the labour mind. Unemployment has meant much in many skilled trades in the past, and is the subject of many bitter memories. No great number of years ago the wages in many trades left little or no margin for a rainy day, and periods of slack trade proved hard for many workmen and their families. The feeling of protest against the possibility of the repetition of these experiences has an intensity with the working man which it is difficult for the outsider to realise. This helps to explain an opposition which in some aspects appears almost incredible.

In this matter of unemployment the unions should remember that conditions in the future are never likely to be what they were in the past. Unemployment insurance covering all workers in some form will probably come into being in no great number of years, and in the Bill which is being brought forward by the present Government all organised workers are covered, except domestic servants and agricultural labourers. This, in itself, practically meets any case which has been raised by the unions which have opposed the training and entry of ex-service men. It is true, or we trust it is true, that under any unemployment scheme which is adopted the out-of-work benefit will not approximate to present wages, and it will not pay even the laziest individual to deliberately remain out of work. The institution of universal out-of-work benefit will, however, take the deepest sting out of unemployment and will make some of the memories of our workmen a record of an experience which their children will never know.

This matter of the getting into civil employment of all discharged navy and army men has, however, another aspect, which is the most important of all. The opposition with which we have been dealing being based on the fear of unemployment bring us to the old fallacy of the work fund. It is said there is only so much work of a kind to do, if we admit more men to our union to help to do this work then there will be less for the men who are already in, and consequently they will suffer from more unemployment. The subtlety and danger of this doctrine lies in the fact that in limited and individual cases it may be true. This probably explains its pertinacity. If an isolated firm in a small town has a certain amount of work of a special kind, and they take on a number of extra workpeople to enable them to get through with it, then clearly the work will be finished sooner than if they restricted themselves to their original number of workpeople. Consequently, if the work is not followed up by something similar, the original workpeople may be out of employment at any rate sooner than would otherwise have been the case.

To look at this matter in another and rather broader way. The average amount of unemployment in any industry over a number of years will be a function of the average amount of work to be done in that industry, and the number of workpeople it employs. If by reason of specially high wages or other artificial condition too many workpeople are attracted to the industry, then on the whole the workers of the trade will suffer from more than the average of unemployment. Contrariwise, if an industry for any reason is kept permanently short of labour, and assuming the industry is an important one not likely to die out, then the workers will, on the average, suffer less from unemployment than if the industry was properly staffed. This

latter condition sounds attractive to certain labour minds, and it is at the bottom of schemes to limit the number of apprentices and of the opposition to the entry of discharged service men.

We have stated the conditions leading to employment and unemployment in the above paragraph in a somewhat dangerous way. For the sake of simplicity we have told only half a tale. What we have said is correct, but there are further factors which enormously modify the effect of the simple relations we have considered. No industry can be taken alone, and no body of workpeople can profitably act as though they and their proceedings concerned their particular trade only. To hamper one trade is indirectly to hamper many, and the workpeople who apparently gain by restricting the available labour in their own industry, will themselves suffer in other ways as a consequence. All industry is bound together, and it is to the final advantage of every individual workman that every industry should be as busy and profitable as possible. If, for instance, the output of machine tools is limited by artificially limiting the number of workpeople available for making them, then either some other industries are prevented from being established or being expanded, or the machinery is made abroad. In either case the workman who thought to help himself suffers directly in the costs of everyday commodities and possibly helps in the undermining of the stability of his own trade in such a way that ultimately he will suffer from more unemployment than he would ever have met in normal seasonal or cyclic variations.

With a keen appreciation of the limitations of human nature we do not wish to preach that the bricklayer should admit dilution in his trade so that the South Sea Islander can buy cheaper calico. We want him to admit dilution so that he himself can buy cheaper shirts. We hesitate to use the word "production." We have seen it in print several times of late. We do however wish to point out that if the work fund fallacy is ever to receive its quietus, now is surely the time. The building trade should be object-lesson enough. The work fund in the building trade now stretches beyond the limits of any human vision. The building of houses will lead to the building and extension of factories. The building and extension of factories leading to increased trade and prosperity, will lead to the further building of houses, halls, theatres, &c. This prosperity will also lead to further factories, and will bring into the region of possibility the amazing programme for the rebuilding of our hundreds of miles of slums.

There is nothing isolated about the building trade, however. Every productive industry now calls for expansion, and in as much as that expansion is achieved, every other industry and every worker in every other industry benefits. One cannot improve on St. Paul in this matter. His images did not refer to the body politic, but his phrases are very applicable. "We have many members of one body and all members have not the same office" . . . "Whether one member suffer, all the members suffer with it; or one member be honoured, all the members rejoice with it." There is room and to spare in productive work for every discharged service man in the country, and in so far as the trades unions are able to keep these men out of industry they are not only indulging in very bad electioneering, but are directly injuring themselves and their own members.

## POSITIVE RAYS.

On the afternoon of Saturday last, the 21st inst., Sir J. J. Thomson, O.M., P.R.S., Master of Trinity, delivered at the Royal Institution the first of a course of six lectures on "Positive Rays." In his opening remarks the lecturer stated that the scope of this course of lectures would be somewhat wider than the above quoted title might at first suggest. The study of positive rays had, it was true, formed the starting point for much of the research work with which he proposed to deal, yet, as was often the case, these investigations had developed and spread out into regions which had little direct connection with the rays in question. The title he had chosen must therefore be understood as merely a text on which he might speak generally about electrical methods of studying the properties and constitution of matter. To these methods we owed the discovery of the electron, which now played such a fundamental part in all physical and chemical processes. These electrical methods, moreover, provided the best means of determining the mass of a molecule and the number present in a unit of space. The atomic theory again had been rescued by these methods from the attack made on it by chemists such as Ostwald, who had urged that there was no necessity for this theory as all the phenomena which had led to its framing could be explained by energetics. To this attack physicists had replied by showing effects produced by individual molecules. The powers of these electric methods of investigating matter were still far from exhausted in this enumeration, and interesting refinements made since the war had led to the discovery of new substances. It had been shown that the positive rays provided the best method of fixing atomic weights and of these long series of determinations had been made in the Cavendish laboratory. If these recent determinations were to be trusted, it would, the speaker thought, be agreed that some revolutionary changes would be necessary in some of the values hitherto accepted by chemists.

One strong reason for the success of these electrical methods was due to the fact that it was very much easier to detect the small charge of electricity carried by an atom or a molecule than it was to detect one of these by its weight. We were, perhaps, somewhat apt to be dazzled by the delicacy of the micro-balance, which was capable of weighing the millionth of a milligramme, but the number of individual molecules in such a mass was stupendous. To indicate briefly exactly what was going on in the most refined of these weighings Sir Joseph Thomson used the following analogy: Let the whole of the war debts of the Allied and enemy powers be capitalised in pennies, then if the financier had no more delicate method of detecting a penny than a chemist had of weighing a molecule the financiers, confronted with the above mass of capital, would be just beginning to suspect that such things as pennies existed, but could not be quite certain of the fact that there really were pennies moving about.

The weight of a molecule was possibly not the most delicate means at our disposal for detecting it. For example, although, relatively speaking, the sense of smell was almost extinct in man, we could detect the presence of one part of ozone in a million parts of air, and in the case of perfumes such as myrrh, the amount which could be detected by the nose must be very small indeed. He would like to see experiments tried with hounds, which he thought might yield results of a quantitative nature showing how small an amount of matter spread through a given volume could be detected by a highly developed sense of smell. Were such an experiment found practicable he thought that the results would put the micro-balance far in the shade as a detector of mass.

Over and above the fact that it was easier to detect the presence of an electric charge on an atom than to weigh the atom itself there was another reason why electrical methods had proved more powerful than chemical in investigations on atoms and molecules. By means of these electrical methods we could put more energy into an atom or molecule than was possible in any other way. The more energy carried by an atom the easier it was to detect it. In the case of an ordinary gas the only non-electrical method of increasing the energy transported by an atom or molecule was to heat the gas. It turned out, however, that little could be done in this way. The average energy carried by a molecule of a gas at the ordinary room temperature could be represented by the work done in pulling an electron through one-thirtieth of a volt. In order to increase the energy carried by the atom to the amount represented by pulling an electron through one volt it would be necessary to raise the temperature to about 6000 deg. C., a limit which was not attainable in our laboratories. In electrical methods of studying gases, however, the charged molecules could be pulled through as much as 100,000 volts and could thus be given an amount of energy incomparably greater than was feasible in other ways. This was well illustrated by the spinthariscope in which we saw that the energy carried by each single charged molecule was so high that it produced a flash of light when it struck the phosphorescent screen. This phenomenon had been used by Sir Ernest Rutherford to count the number of molecules emitted in unit time by a mass of radium.

The great advantage of electrical methods of studying atoms and molecules lay therefore in the fact that we were able to endow individual particles with an amount of energy which was relatively speaking, almost unlimited, though as measured in ergs its absolute amount might make but a poor showing.

The discovery of what were now known as positive rays was due to Goldstein, who in the course of a life of 50 years devoted to the study of the passage of electricity through gases, observed that if he used for his cathode a perforated plate instead of a solid one a radiation streamed through these holes to the space at the back of the plate. When the gas in the tube was hydrogen the colour of the light here was red, whilst the space on the other side of the perforated cathode was filled with the usual greenish luminosity due to the cathode rays. Further investigation showed that whilst these cathode rays were readily deflected by a magnet the streams of red rays at the back of the plate were apparently unaffected by the near presence of a magnet. It was now known that these canalstrahlen, as Goldstein called them, consisted of streams of rapidly moving particles, each carrying a positive charge.

An interesting point established by Aston was that in conditions otherwise similar a larger current flowed through the discharge tube when the cathode was perforated than when it was whole, and what was more remarkable still the discharge was brightest just in front of the holes. These observations had a direct bearing on the question as to how the current passed from the gas to the cathode. During a discharge we had a stream of positively charged particles, moving towards the cathode, and the flow of the current depended on the possibility of these particles losing their charge when they reached the cathode. A positively charged particle was one which had lost one or more electrons. In order to lose its positive charge, the particles must therefore capture an electron, and how this was done constituted the whole problem of the passage of electricity from the gas to the metal.

Using a non-perforated cathode it was found that quite close to this cathode the electric force was very large, and hence any electron that might be close to the plate would be exposed to an intense force and acquire a correspondingly high velocity. As a consequence such electrons would tend to rush past the upcoming positively charged particles, affording the latter little opportunity for making the capture necessary to the loss of their positive charges.

When, however, the cathode had a hole in it, the electrons shot off from the metallic boundary of the hole could only go across to the other side and hence the hole filled up with an accumulation of electrons moving but slowly and thus more readily captured by a positive particle. Such holes in short acted as aerodromes or easy landing places for the positive particles.

In certain investigations "sandwich" cathodes had been used. One form consisted of two parallel triangular plates electrically connected together, but separated by an air space. When the discharge passed positive rays streamed from the points of the triangle and cathode rays from the middle of the sides. A notable point was that although these sandwich cathodes were placed in the "dark space" of the discharge tube, the air space between the plates was filled with luminosity. This was due to the recombination in this region of the positively charged particles with the negative electrons.

By using sufficiently powerful electric or magnetic fields positive rays could be deflected, but it was not easy to observe this directly as the boundaries of the stream were nearly as hazy as those of a cloud, and exact measurement was impossible. Like the cathode rays, however, they had the property of causing phosphorescence when they struck certain

substances. In the case of the cathode rays, the phosphorescence produced on striking glass was bright enough for quite good measurements to be possible, but the luminescence produced where a stream of positive rays hit glass was not bright enough for convenient observation. The best results were obtained with willemite, a native silicate of zinc. For use this was very finely ground and deposited on the glass of the tube. It phosphoresced brightly where struck by the positive rays, and if a screen were placed between source and target, its shadow was clearly outlined on the willemite surface. In this way it had been proved that the rays moved in straight lines.

Every one who had worked with these screens knew that after a time they got "tired," the spot struck by the rays failing to respond by phosphorescing. This seemed to be true whatever the substance used as target, though the exposure needed might be a matter of hours or days. In some recent investigations Professor Perrin had succeeded in devising means by which this "fatigue" could be detected in the course of a few minutes. His experiments were made with certain dyes which fluoresced under the action of light. To this end Professor Perrin mixed the dye with a sticky substance such as glycerine instead of water, so that the particles were more or less imprisoned, and could not move about as readily as they could when dissolved in water. By arrangements similar to those adopted in ultra-microscopy the illuminating beam was concentrated on a volume which was a minute fraction of a cubic millimeter, and under these conditions only a very few minutes were required to render the particles of the dye inactive or dead.

There was no doubt that luminosity arose in the passage of the phosphorescing matter from one state to another. In many cases the phosphorescing body returned to its original state when the stimulus was withdrawn, but this did not necessarily happen.

The same rule applied when the phosphorescence was due to the impact of positive particles which produced a change, at any rate, in the physical state of the body struck. This was well shown in the case of lithium. This body had a spectrum showing very strong lines in the red, but this spectrum was only yielded by lithium when in the gaseous state. The solid salts gave continuous spectra. Now when salts of lithium were bombarded by cathode rays the phosphorescence produced was blue and the spectrum observed continuous, but when the phosphorescence was produced by positive ray bombardment, the light was red in colour and gave the line spectrum of lithium, thus showing that the lithium had been vaporised. In some cases fluorescence was due to the decomposition of a body or its departure from its original state. In others the fluorescence was observed during the return to the original state. This was well shown by oxygen. Using a tube consisting of two bulbs communicating through a narrow neck, the lecturer showed that on passing a discharge between electrodes in the lower bulb a certain luminosity appeared in the upper bulb. This he stated was due to the diffusion into the upper bulb of ozone produced by the passage of the discharge in the lower bulb. As the ozone reverted to the normal form of oxygen it gave out light.

Raising the temperature accelerated the return so that instead of having a feeble luminosity spread over a considerable time, we might get merely one bright flash. The phenomenon of thermo-luminescence could thus be accounted for. Certain substances, it was found, phosphoresced very fully after being suitably stimulated, but on heating them they would give out quite a bright light for a short time.

In subsequent lectures Sir Joseph said that he would describe how in certain cases the phosphorescent screens he had mentioned could be replaced by photographic plates. These had the great advantage of providing a permanent record which could be examined and measured at leisure. On the other hand, there was the disadvantage that, as they required development, it was not possible to discover during the progress of an experiment whether matters were proceeding as intended.

## THE PROLONGATION OF PATENTS.

A DECISION by Mr. Justice Sargant reported last week deals with a point in the procedure to be adopted in connection with petitions for prolongation of patents which would, except for the provision incorporated in the Patents Act of 1919 extending automatically the lives of patents in force at the commencement of the Act for a further period of two years, shortly expire. The facts are as follows:—A patentee whose patent would normally have expired in July, 1920, wished to have the term of his patent extended and, before the Act of 1919 had passed, issued the necessary advertisements preparatory to presenting a petition to the Court. A few days after the new Act became law, the patentee filed his petition for prolongation. The question then arose whether the petition was to be heard or to stand over or what was to be done with it.

In a petition under Section 18 of the Act of 1907, the Court, in considering a petition for prolongation of a patent, has not only to consider the nature and merits of the invention in relation to the public, but also, which is more important, the question whether the patentee has been adequately remunerated by his patent. The Act of 1919, as pointed out, automatically extends for two years the lives of patents in force at the commencement of the Act. The patent in question was thus automatically extended until July, 1922. Mr. Justice Sargant pointed out that a petition for prolongation filed two years before the expiration of the patent term, as in the case under consideration, would, under ordinary conditions, be refused as premature, as the great reason for prolonging a patent was that the patentee has not been thereby adequately remunerated, and the question whether a patentee had been so remunerated could not be answered until nearly the end of the term for which the patent was granted. The proper course seemed to Mr. Justice Sargant to be to adjourn the petition generally and to apply later on for its restoration.

Patentees who have been considering the question of presenting petitions for prolongation of their monopoly rights and whose patents have been automatically extended under the new Act, must therefore defer their petitions until the extended periods have nearly expired.

The decision does not deal with the position of patentees who, by reason of the recent hostilities have suffered loss or damage (including loss of opportunity of dealing in or developing their inventions, owing to their having been engaged in work of national importance). Their position is not clear; the amendment made to Section 18 of the Act of 1907 by the Act of 1919 is not mandatory but permissive, and while the Court has power to have regard solely to the loss or damage suffered by patentees by reason of the recent hostilities, it may nevertheless consider the nature and merits of the invention in relation to the public and the question of adequate remuneration of the patentee. It may well happen that patentees have suffered loss or damage by reason of the war and yet, in the view of the Court, have been adequately remunerated. It probably will be useless for patentees who allege loss or damage to apply for prolongation much before the expiration of their patent terms, as the question of adequate remuneration will be certain to crop up, and such question cannot be entertained, as Mr. Justice Sargant points out, until near the expiration of the patent term. The amendment contained in the Act of 1919 does not appear to put patentees who allege loss or damage due to the war, in a better position as regards applying for prolongation than they would have been under the Act of 1907, except that a patentee who alleges loss or damage has a cheaper method of procedure open to him than is the case if he applies under the provisions of the Act of 1907.

## ELECTRICAL DEVELOPMENTS IN VICTORIA.

NEWS is to hand from Victoria of an important decision concerning the production of electricity and the utilisation of large brown coal deposits in that State. Two important deposits have been considered with relation to the production of power primarily for future developments in Melbourne. One deposit is at Altona, about 11 miles from that city, while the other is over 60 miles distant. The coal at the former point is a 72-ft. seam found at a depth of 349 ft. It is said that almost immediately below this deposit artesian water is encountered, while above it is a soft sandy clay. Extensive underground mining would, it is expected, meet with difficulties from both these factors, which are absent in the more distant field at Morwell. There the seam of coal is said to be about 174 ft. thick with only about 33 ft. overburden, so that it could be mined by the open-cut method at a cost which is placed at 2*s.* 3*d.* per ton, compared with a cost of about 7*s.* 1*d.* per ton for the Altona coal.

The Morwell deposit is said to be comparatively safe as regards artesian water, and little difficulty is anticipated in dealing with seepage water in the workings. The price of Newcastle (New South Wales) coal delivered at Melbourne is on the same base 25*s.* 3*d.* per ton. However, the latter is a good coal, whereas the brown coals have a value of only about 6,500 British thermal units. The Morwell field is much more extensive than that at Altona. Bores have proved the existence of about 150,000,000 tons of coal in a limited area, capable of being won by open cut, while the estimated field is supposed to contain about 20,000,000,000 tons. The present scheme proposes therefore open-cut mining with mechanical appliances, such as are used on the lignite mines near Cologne, Germany. There would be installed at first a steam generating station of 50,000 kw. capacity, with three 25,000-kw. units, one being in reserve. The transmission line will be a single line of towers with two circuits on it.

The report in which this scheme is outlined has been drawn up in compliance with the Victoria Electricity Commissioners Act, 1918. It has now been adopted by the Victorian Government and the necessary Bill has been passed. Steps are being taken to push on at once with the scheme, and it is hoped that bulk supply to Melbourne will be possible in 1923. The initial cost of the scheme is placed at about 3,000,000*l.* Of this sum, about 221,000*l.* will be required for opening up the mines at Morwell. The power plant there, comprising three turbo-generator sets of 25,000 kw. each, eight boilers each of 14,010 sq. ft. heating surface, coal and ash-handling plant, auxiliaries, buildings, switchgear and transformers, is estimated at 1,442,927*l.* Provision would be made for possible extension in the future to 100,000-kw. capacity. The transmission line will ultimately consist of two lines of towers, of which one is to be put in first at an estimated cost of 323,102*l.* The terminal station at Melbourne is put at 226,755*l.* The transmission voltage proposed is 130,000, reduced to 20,000 at Richmond for supply to city substations at which it would be reduced for distribution to 6,000 volts or 4,000 volts. The sum of 251,058*l.* is allowed for Melbourne substations and equipment, and 272,550*l.* for distribution cables, &c.

An estimate is given for the annual cost of working this scheme and supplying power to Melbourne, on the basis of a load factor of 42 per cent. The total annual cost works out at 222,045*l.*, compared with 243,627*l.* for a corresponding scheme of supply from the Altona coalfields, and 280,035*l.* for the cost of generating an equivalent amount of power at Melbourne from seaborne coal. On this basis, therefore, the Morwell supply is so much cheaper that it is expected the Melbourne generating plants would ultimately shut down, their requirements being satisfied from the Morwell scheme.

The coal is to be used in travelling-grate furnaces. Victorian brown coal has already been used at the Melbourne City Council's power house, to the amount of several thousand tons lately, and it is expected to be able to use it without previous drying. The gasification of the fuel, with the use of the gas under the boilers, and recovering the by-products, will not be attempted at first, though it has received consideration.

The scheme is considered to afford a good opportunity for laying out a model township at Morwell, and 150,000*l.* is put aside for this purpose. The estimates also include a sum of 30,000*l.* for a briquetting plant, as it is thought that a con-

siderable demand for briquette fuel might be developed.

The only alternative supply scheme for electrical energy in bulk is based on the water supply of the Kiewa River. This would mean plant situated 133 miles from Melbourne, and only about 35,000 kw. can be assured as a continuous supply, without the possibility of extension. The cost of this scheme, coupled with the impossibility of expansion, militates against it when compared with the Morwell project.

## THE BIRMINGHAM INDUSTRIAL FAIR.

The British Industries Fair at Birmingham was formally opened by the Lord Mayor of the city, Mr. W. A. Cadbury, on Monday last, and if the congestion of the hotels in Birmingham is any criterion of the number of buyers who are visiting the fair, the success of the latter is more than assured. The Birmingham Fair is, as generally known, an integral part of the British Industries Fair organised by the Board of Trade and is being held simultaneously with other fairs at London and Glasgow. Each fair is designed to be representative of the typical industries of the neighbourhood, and in order to concentrate the exhibits of similar products for the convenience of buyers it has been arranged that each manufacturer shall show at the fair his goods most appropriate to his particular industry, independently of the geographical position of his factory. In accordance with this scheme we find at Birmingham exhibitors from Glasgow, Dundee, London and other distant cities as well as from the dense industrial area of which Birmingham is the focus, the nature of their products being the controlling factor. It may be mentioned, as a sign of the times, that stands are also held by manufacturers from four Canadian cities, namely Hamilton, St. Catherines, Hull and Guelph in Ontario.

The Birmingham municipality and Chamber of Commerce, to whom the credit for the local organisation is due, were fortunately able to secure three very large permanent brick buildings which had formed part of the aerodrome at Castle Bromwich, and these, together with space at the Town Hall and the Art Gallery, provided excellent accommodation for their enterprise. Some 625 exhibitors have been housed, a task which in view of the limited number of suitable buildings in the city could never have been adequately performed without the facilities of the aerodrome. The latter adjoins Castle Bromwich station, which can be reached in a quarter of an hour from the centre of the city, and the lofty rectangular buildings, free from obstruction by internal walls, are admirably adapted for exhibition purposes. Full advantage has been taken of the opportunity thus afforded of arranging the exhibits in a systematic manner. Instead of the haphazard collection of articles which so often does duty as a trade exhibition and which makes inspection so tedious and unsatisfactory, we have in Birmingham a judicious segregation of similar products into groups, classes and sections, so that a buyer can go straight to the section in which he is interested and inspect in a short time the whole range of the exhibits which concern him. An equally praiseworthy sense of order and convenience has been shown in the official catalogue which is printed in English, French and Spanish. For the greater convenience of buyers it is exhaustively indexed, there being well over 2,000 different names of articles tabulated alphabetically in each of the three languages, together with the number of every stand upon which the respective articles are to be seen. In the arrangement both of the exhibits and the catalogue Birmingham has set a standard far in advance of anything which has been usual in trade exhibitions in London, and we hope the precedent will be followed.

The trades more particularly associated with Birmingham and the neighbouring towns are those connected with brass-working, sheet-metal working, gun-making, cycle-making and the manufacture of almost every kind of household fittings and domestic utensils. Ornamental brassware such as lamps, chandeliers, bedsteads, &c., occupies a considerable amount of the space at the fair, but we noticed no sign of the cheap jewellery, &c., which is often associated with the city by the disparaging title of "Brummagem goods." It is possible that the reputation of Birmingham art and workmanship has suffered undeservedly in the past from the belief that many of the shoddy products of Germany have emanated from the Midland city. At any rate, there is nothing at the fair of which any city need be ashamed, but, on the contrary, there is a vast collection of goods which could not be equalled in quality or design by any manufacturing area in the world.

The preponderance of the brass and kindred trades in Birmingham, is reflected by the fact that, according to the catalogue brass sheets are exhibited by no less than 43 different stands, brass strips on 42 stands, brass tubes on 27 stands. Similar products in copper appear to be equally numerous. There are 18 stands exhibiting nickel ingots, and about an equal number showing nickel-silver in the form of wire, sheets, &c. Aluminium cooking utensils are shown on 11 stands, kettles on 15 stands, hearth furniture on 18 stands, cycles on 19 stands, folding baby carriages on 7 stands, and so on. These examples, selected almost at random, will give some idea of the general nature of the fair. It would be quite impossible to enumerate the vast variety of articles which may be included under the head of household fittings, from door handles to chandeliers, and from baths to bedsteads, but they all seem to be adequately represented. We have, however, said enough to indicate the classes of goods which a visitor will find most prominently displayed, although pneumatic tyres, telephones, gas stoves, and wire goods are also important sections of the fair. The amount of drop-stamper work which is to be seen is illustrative of how this art is superseding that of the blacksmith and the moulder in many directions. Machinery of any kind is almost entirely absent, and the high-speed steam engines and stamping presses for which certain Birmingham firms have earned a world-wide reputation are not represented at the fair at all. The most imposing exhibit of a mechanical nature is that of Messrs. W. and T. Avery, Limited, who show a large collection of automatic and other weighing machines, testing machines, &c. Messrs. Lee, Howl and Co., Limited, of Tipton, Staffs., exhibit a good selection of boiler-feed pumps, hand pumps, &c. Messrs. John M. Terry and Co., of Queen Victoria-street, E.C., show spinning lathes, and there are a few other mechanical exhibits, but speaking generally it may be said that the fair is devoid of machinery. The Gun Section of the fair is segregated in the Birmingham Art Gallery.

The great majority of the exhibits at the Birmingham Fair are not such as would be suitable for description in our pages, but with a few of them which appeal directly to engineers, we shall deal with more fully later. It may not be out of place to warn visitors of the absolute impossibility of getting hotel accommodation of any description at Birmingham at the present time. This state of affairs was, however, foreseen by the Chamber of Commerce, who, in accordance with the careful organisation which has marked their work in connection with the fair, took early steps to secure a list of available apartments in private houses in the city, and thus can render a much appreciated service to visitors who have come to Birmingham for the fair.

## WAR-TIME STRIKES.

Though the matter is of greater retrospective interest than present value, the figures just published in a Blue Book issued by the Ministry of Labour relating to labour disputes during the recent war are well worth more than momentary attention. It is true that strikes and lock-outs never reached during the war the large totals of 1914, and we are thankful that the figures are not, in a general sense, reflective of the attitude of those who stayed at home, towards those who were risking everything for them abroad. Yet it cannot be wondered that, in the bitterness of the moment, our men overseas sometimes even asked if the country was worth so great a sacrifice as they were prepared to make for it, when those they had left behind sordidly wrangled over wages and other trifles instead of putting patriotism before profit. What came to be known as the "stab in the back" was very keenly felt by our forces at the Front to the extent, at times, of completely demoralising individuals. If it had not been for the wonderful collective *morale* of our forces which to an extraordinary degree characterised our troops when anything wanted doing, to the absolute subordination of private feelings, such effects might well have led to disaster. It is doubtful if those who stayed at home ever realised the psychological effect of their actions on those in the trenches. We give them credit so far that we believe what they did was done from ignorance and the narrowness of view which it carries with it, rather than pure selfishness, which it certainly resembled judged from the fighting line.

It is a curious fact, and points, if not directly to a somewhat self-centred attitude, at least to some form of sub-conscious selfishness, that when matters at the Front were inclining temporarily against us, there were few labour disputes at home; while, on the other hand, if the battle operations were favourable the number of disputes largely increased. The year 1914 had been one of continual unrest up till the time of the great danger. Disputes at once diminished, till in December very few indeed troubled the country, as it was endeavouring to settle down seriously to the struggle before it. In the following summer when we had made good our position in France, there occurred the South Wales coal strike, involving over 200,000 workpeople, a number which nearly equalled the worst months of so-called peace, in the early half of 1914. Again during the Loos offensive and that in Champagne in the fall of 1915 disputes again increased. In 1916 and during the battle of the Somme the figures were comparatively low; lessons at this time were beginning to be brought home to this country by the heavy losses by submarine warfare. In 1917 when America entered the war, our country seems to have thought the time opportune for a little diversion in the way of strikes, involving about 240,000 workpeople, mostly, to our shame be it said, in the engineering trades. This time the country came to its senses fairly quickly, but towards the close of the year when our advance was being made on Cambrai, and our efforts had succeeded in breaking the back of the opposition in Palestine, the figures of disputes again went up to a record—this time mainly due to the aircraft workers, at a time when we were just beginning to reap the benefit of our hard won superiority in the air. Again, through the dark days of early '18 the figures were low, but once more the movement raised its head in the summer when a favourable turn attended our efforts in France. In this case the trouble was of a miscellaneous character, and affected London traffic, the Yorkshire miners, the police and so on, with the cotton strike shortly after. On the close of the war the figures again went up, but that is apart from our present subject.

Most of the disputes arose over wages, and it is rather remarkable that this should have been so when so many of our men had not only voluntarily but cheerfully sacrificed good jobs and steady pay for the mere pittance given to an infantryman, accepting the risk of being killed into the bargain. On the other side, it must be admitted that the soldier was not at the time troubled by the rise in the cost of living, while practically every wages strike was ostensibly based on this, and as most succeeded to a greater or less degree in procuring an advance, conceded *nolens volens* to get the industry at work again, each success proved the stepping stone to more demands. Whether constant concessions were the best remedy is doubtful. The men in the trenches would have liked now and then to see the protection granted to munitions workers at home withdrawn and the recalcitrants compelled to put in some time at the front, from which they would probably have returned sadder and wiser men—if they returned at all. However, this is the darker side of the picture. There is another. It shows that arbitration served an excellent purpose during the war in these matters, and to a constantly increasing extent. For instance, in 1915 only 141 cases were settled by the Interim Court of Arbitration set up under the Wages Act. The figure rose to 2,298 in 1918. In the same years single arbitrators had settled 3,664 cases. Again, it is with great regret that we have to record that out of a total of about 8,000 settlements, 2,765

cases arose in connection with the engineering and shipbuilding trades. Perhaps, again, we may look at the brighter side and infer from this that these are intelligent men who, realising that there might be more than one side to their question, were willing to abide by a just decision. But for all this we can only have regret for the fact that these conditions of industrial life at home were considered necessary when a good portion of the nation, recruited from both sexes, were living under most abnormal conditions, sustained in the great national effort by far loftier ideals.

## EDUCATION AND RESEARCH IN AERONAUTICS.

SOME few years ago Sir Basil Zaharoff founded Chairs of Aviation in Paris, Petrograd and London. As far as we know this was the first definite step towards building up an educational course deliberately designed for the future aeronautical engineer. In Paris and London these chairs are in active being, and professors have been appointed. The state of the matter as far as Petrograd is concerned we know nothing of. The London chair is held at the Imperial College of Science and Technology, and Sir Richard Glazebrook is the first professor. This choice has been a happy one. Apart from the fact that from the first Sir Richard Glazebrook was responsible for the aeronautical research work carried out at the National Physical Laboratory, and has been closely connected with the corresponding work done at Farnborough, Sir Richard was also chairman of the Committee on Education and Research in Aeronautics, which was formed by the then Air Minister, Lord Weir, in October, 1918. We say the choice has been very happy because the report which this committee has just presented shows close touch with all existing workers in this field, and puts forward workable and valuable proposals for a comprehensive scheme of aeronautical education and a co-ordinated and allied scheme of research. Without wishing to detract in any way from the labours of Sir Richard Glazebrook's coadjutors we suggests that his exceptional experience in this branch of work has considerably contributed to these final proposals.

The committee points out that education and research are closely interrelated. In saying this they are referring to advanced education of the post-graduate order, and this is the class of education with which they have concerned themselves. The basic work on which the after career of an aeronautical engineer must be based does not differ from that required by an engineer in any other branch of the profession. An advanced study of aerodynamics, aircraft engines and such problems of meteorology and navigation as attain importance in connection with aircraft must necessarily be to a considerable extent experimental, and the later stages of such experimental work are not to be distinguished from research.

The scheme of the committee is timely. During the war this country obtained the lead in aeronautical research, but the industry to which that research administered is now to a large extent paralyzed. Without some co-ordinated scheme and without monetary support from either the Government or private benefactors it is likely we may lose the lead we have gained to the risk not only of military efficiency, but also of the future of an industry which with time must advance from its present condition even if it fails to re-attain the amazing activity of war time. Since the commencement of practical aeronautics, research has been directed by the Advisory Committee for Aeronautics which was appointed by the Prime Minister in 1919. The duty of this committee was to superintend the investigations carried out at the National Physical Laboratory and to give advice on aeronautical problems arising in connection with the work of the Navy and Army. During the war, in addition to the work at Teddington, the committee has been connected with, but has not had control of, the full scale work at Farnborough. It has also been in touch with the full-scale work on seaplanes carried out at the Isle of Grain and Felixstowe, and the airship work at Kingsnorth and Pulham. The Advisory Committee as a co-ordinating body has been of great value, and the report we are dealing with proposes to retain it under the name of the Aeronautical Research Committee, and considerably extend its scope.

It is recommended that this Aeronautical Research Committee should be constituted in connection with the Air Ministry and that it should include representatives of the department or departments responsible for naval and military aeronautics and the regulation of civil aerial transport. It should also include representation of the Department of Scientific and Industrial Research, including direct representation of the National Physical Laboratory, as well as representatives of the aircraft industry, the Imperial College and other special members of special scientific attainments. The duties of this composite body would be to advise generally on scientific and technical problems relating to the construction and navigation of aircraft, and undertake and supervise research concerning the same matter. It would co-operate with the Governors of the Imperial College in the promotion of aeronautical education. The committee would also co-operate an Industrial Research Association for the aeronautical industry, which it is proposed should be established under the Department of Scientific and Industrial Research in the same way that research associations have been formed in connection with other industries. In view of the cost of much aeronautical research it is intended that in the main the work should continue to be carried out at the National Physical Laboratory, Farnborough and other similar centres, but there is no intention of attempting unnecessary centralisation, and it is proposed that the committee should encourage all practicable independent research at other centres.

The educational proposals of the report suggest in brief that the higher branches of aeronautical education should be centred at the Imperial College. The reason for this is partly one of expense and partly owing to the realisation that the number of post-graduate students in aeronautics is bound to be comparatively small. Before the war the yearly total number of honours graduates in all branches of engineering taken together from all the universities of the United Kingdom averaged about two hundred. Another reason for expecting but a limited number of students is that the ultimate posts available in industry and in the services for such honours men cannot be very large. The advantages of choosing the Imperial College as the seat for the higher aeronautical education are that it is within easy reach of Teddington and Farnborough, and it is an essential feature of the proposed post-graduate courses that actual model and full-scale research and practical flying should form important features.

Another obvious reason for choosing the Imperial College is that the Zaharoff foundation forms a nucleus on which the necessary organisation and teaching staff can be built up. It is proposed that professorships in aerodynamics, airship construction, &c., should be built up, and that the Zaharoff Professor of Aviation should act as Director of the School of Aeronautics. Allowing for lectures, salaries, laboratory expenses, &c., it is estimated that the cost of the teaching staff, &c., would amount to 10,000*l.* a year. The whole scheme appears an adequate and well-worked-out one, and it is to be hoped it may go forward. At present, as we understand, the only actual feature of this scheme in existence is the Zaharoff professorship. Clearly the professor, Sir Richard Glazebrook, cannot do very much absolutely alone. As a preliminary, Sir Richard is, however, delivering a course for introductory lectures on Wednesdays at 5 o'clock, at the Imperial College. These are open to the public on application for tickets to the Registrar. The first lecture took place on the 25th inst., and was concerned with the development of the wind channel and the elementary consideration of the relation of model and full-scale experiments. The course continues each week until March 24 next.

LAUNCH OF A LARGE STEAM TRAWLER.—Messrs. Cochrane and Sons, Limited, Ouse Shipbuilding Yard, Selby, state that they launched, on the 21st inst., the steam trawler Patrie for French owners, the dimensions of the vessel being 200 ft. by 32 ft. by 16 ft. This is believed to be the largest trawler in the world.

## NOTES.

### THE KITCHEN RUDDER FOR FISHING VESSELS.

THE Kitchen reversing rudder, a description of which was given in our issue of May 16 last, appears to be making considerable headway in commercial application. Experience is leading to its use on boats of a larger size than were at first fitted, and we understand a set is now going through for a boat having a propeller 4 ft. in diameter. The boat is a fishing drifter. This application directs attention to a valuable property of the rudder. The oil engine driven fishing vessel frequently finds it difficult to travel at a sufficiently slow speed when handling nets owing to it being impossible to run the engines slowly enough. The fitting of a Kitchen rudder entirely eliminates this difficulty, as by closing the deflectors sufficiently the speed may be brought down to a fraction of a knot with the engine running at its normal revolutions. As was pointed out by Mr. A. T. Wall, in a paper read before the Liverpool Engineering Society on the 4th inst., this property of the Kitchen rudder should also be of importance in connection with oil-engine driven tugs. Mr. Wall dealt with the evolution and application of the rudder in a general way and gave details of various installations. His paper included some interesting figures showing the way in which the rudder could be applied to a 300-ft. cross-Channel twin-screw steamer.

### A LARGE ELECTRIC LOCOMOTIVE.

A few details of a large direct-current electric locomotive were given in a recent number of the *Scientific American*. The locomotive in question was built by the General Electric Company for the Chicago, Milwaukee and St. Paul Railroad for working over mountainous grades. It is 78 ft. in length and weighs 265 tons, of which 229 tons are on the driving wheels. It has altogether 14 axles, and the motors are gearless and direct-connected. The voltage for which it is designed is 3,000, and it is capable of developing 3,240 h.p. In normal service the locomotive is to handle 12-car trains weighing 960 tons, on a 2 per cent. grade at 25 m.p.h. It is fitted with regenerative control, for braking on the mountain sections when running down grade. A somewhat spectacular demonstration was recently given of the power of this locomotive when it was pitted against two large steam locomotives of the New York Central. Details of the latter are not given, so that it is not possible to draw any useful conclusions. At a given signal all three locomotives were started up and the steam engines for a short while pushed the electric machine backwards. As the latter developed its power, however, the steam engines were gradually pulled up and then the electric machine gathered headway in its turn. In another test the steam engines pushed the electric machine over the road till, on a signal, the regenerative braking gear was put in, and after a short while the steam engines had as much as they could do to make headway at all.

### AUTOGENOUS WELDING IN FIRE-BOXES.

An interesting note is given in the 1919 report of the Bureau of Boiler Inspection of the Interstate Commerce Commission in the United States, regarding autogenous welding in locomotive fire-boxes. It has been the custom for some time to use this system of welding for the crown sheet seams of large steel fire-boxes. An investigation of the failures of a number of boilers so treated has led to the conclusion that such seams fail with a higher water level and consequently lower temperature of the sheet, than others, and in many cases have caused initial rupture with, in some instances, slight overheating. It has been found that 80 per cent. of all such welds involved have failed at the time of explosion, and it is recommended that this process should be avoided where the strength of the structure is dependent upon the weld. It may be added that the use of this system for locomotive fire-box work has been the subject of a good deal of discussion, with the result that something like standardised rules have been adopted for patch welding and repair work. In all these welds it is customary to thicken up the joint to some extent, the filling of the V being rather in excess so that at this point the finished job is rather thicker than the plate. This

practice is known at times to have been allowed to go to extremes, and one of the rules now prohibits the thickness of the reinforcing being more than ⅛ in. greater than that of the plate. Excessive thickness is known to have resulted in overheating, and possibly the cases referred to have arisen through this. At the same time one cannot ignore the fact that this form of welding may, in the hands of men not thoroughly skilled, have a very injurious effect on the steel of the plates, while there may also be some further effect which renders the weld itself liable to failure at high temperatures. The failures recorded will probably lead to a more cautious attitude towards the general application of this system to fire-box work.

### Japan.

The war has, of course, been the means of bringing an enormous amount of trade to Japan, and so strengthening her financial condition. Not only has the country executed very large orders for the allies, but she has also entered markets during the war which could not be supplied by European firms. In addition her shipping has reaped an extraordinary harvest, so that the country is now in a much better position than before the war. The dividends being paid by the various shipping companies are exceedingly good, three paying over 100 per cent., one 70 per cent., one 60 per cent., and so on. The net earnings of steamship companies were more than three times in 1918 what they were in 1916, and twenty times as great as in 1912. The amount placed to reserve has grown nearly in the same proportion. At the end of 1917 the country had 2,179 steamers of a total gross tonnage of 1,827,132. The most important classes were of steamers between 2,000 tons and 3,000 tons, and between 3,000 tons and 4,000 tons, which consisted of 219 vessels representing over 600,000 tons. There were 6 vessels of over 10,000 tons each. Most of the steamers were vessels of ordinary speeds, such as 10 knots to 12 knots, only 3 being above 19 knots. The internal prosperity of the country is reflected in the railway and tramway returns. Many of the tramway undertakings are paying dividends of more than 10 per cent., and the net earnings show amounts never before attained. The total net profit from the railways stands higher than ever before, and though the ratio of working expenses to earnings has slightly increased, it is not so high as it was in most of the years before the war. The general activity of the country is shown by imports and exports which have both increased to a phenomenal extent. Exports in 1918 showed an increase of 210 per cent. on the totals for 1913, while imports revealed a rise of 129 per cent. in the same period. Between 1917 and 1918, when the collapse of Russia affected trade with that country, Japan's exports to India increased by 100 per cent. Her exports for pig-iron, &c., to all countries increased by 154 per cent. between 1917 and 1918; bar iron showed an increase of 23 per cent.; machines and machinery 96 per cent.; building materials, 74 per cent.; coal tar and aniline dyes, 147 per cent.; lead, 151 per cent.; and so on, showing that the country has embarked on a very active export business, which in many instances means severe competition with European products. Expansion is shown in all directions and wages are rising steadily. The production of some of the metals, however, showed some falling-off, which was more than made up for by increased output of steel, pig-iron and coal. The wide use of electricity is shown by the fact that in 20,966 factories over 1,163,000 h.p. were represented by the electric motors installed, compared with rather more than 400,000 h.p. derived from water power, 564,000 h.p. from steam, and 40,000 h.p. from gas and oil engines.

### The Training of Shipyard Apprentices.

The general adoption of the 8-hour day has greatly lightened the burden on the ambitious apprentice desirous of mastering the scientific basis of his trade with a view for qualifying ultimately for the higher technical posts. The coming into force next year of the new Education Act will still further promote his progress, as employers will be required to provide their apprentices with facilities for attending classes up to the age of 18. We are glad to note that many of our principal shipbuilding firms are loyally accepting the new conditions and taking steps to ensure that every youth they employ shall have his chance of attaining the qualifications necessary for the higher technical and administrative posts. Hitherto no private firm has offered its apprentices anything like the opportunities open to the clever lad who enters one of the Royal Dockyards. Given the requisite ability, the humblest apprentice there has had his chance of becoming ultimately Chief Constructor to the Admiralty. So efficient have been the educational methods employed that, as noted in the report on apprentice training, just issued by the Institution of Naval Architects, the large majority of the successful candidates for the Institution's scholarships hail from the dockyards. The report gives some valuable information as to what encouragement towards study, apprentices have received in the past from our leading firms, and as to what further proposals are under consideration. A *questionaire* was addressed to 52 firms employing over 25,000 boys and apprentices, of which 4,563 were of less than 16 years of age. The general age of entry for apprentices is said to be between 15 and 16, and, in fact, some firms report that older youths cannot be accepted owing to trade union restrictions. These, moreover, limit the number of apprentices to two for every seven journeymen, but the rule was relaxed during the war. In general the apprentices have been distributed amongst the workmen, who in some cases have received extra pay in consideration of their giving their best aid to the learner. One firm has tried the plan of grouping the boys in a single workshop under a special foreman, and the results have been so satisfactory that it is proposed to extend the system. Very few firms have given facilities for the youths to attend day classes, but most give inducements in the shape of prizes and bonuses to those who obtain certificates at evening classes. The grants in one case were an additional 6*d.* a week for each pass in an elementary subject, and 1*s.* a week for a pass in an advanced subject. Under these rules a boy has earned as much as 14*s.* a week extra pay. Some firms, but not all, have in the past allowed lads attending evening classes to come to work at 8 a.m. instead of 6 a.m. on mornings following class nights. With the reduction in hours and a start at 8 a.m. this concession is no longer needed. Very few firms, it appears, now take premium apprentices. In the case of those intending to take a full technological course at a university, the firms interrogated have commonly in the past preferred the sandwich system, or that the youths should come straight to them from school, but with the new conditions which are to come into force next year, by which facilities for attending day classes must be provided for apprentices up to the age of 18, it is suggested that it will be best for such pupils to take their college course first. One firm emphasises the importance of giving a high grade of education to the able rather than a thin veneer to the whole body of apprentices. Several firms, we note, have of late devoted a good deal of attention to welfare work, providing facilities for cadet corps, outdoor sports and club-houses.

### Inflammability of Mixtures of Air with Ether, Alcohol and Acetone.

The more one studies the question of the ignition-points of inflammable gases, which has been much investigated of late, the more one understands why Viktor Meyer said, in 1892, that it seemed to be almost impossible to determine an ignition temperature. This view is emphasised by the account which Messrs. A. Greville White and T. W. Price, of the Ardeer Factory, Stevenson, gave last December at the Chemical Society, of their inquiry into the cause of the large number of fires which occurred during 1917 and 1918 in solvent-recovery stoves when cordite was being dried. The solvents used are ether, alcohol and acetone, and fires were particularly frequent in stoves from which ether and alcohol were being recovered. The particular problem seemed to be whether and at what temperatures contact with hot surfaces would ignite these vapours. That other will, in contact with warm surfaces, burn with a very pale phosphorescent flame at temperatures not exceeding that of boiling water, and that these "cool" flames may by themselves grow hot, had been known to Davy and Döbereiner. Yet some of their observations gave White and Price something like a shock. Considering that the cool ether flame can become very dangerous, and finding McDavid's soap bubble method unsuitable, as we have stated on another occasion, they decided to determine the "sub-ignition" temperature of ether and other vapours, at which visible combustion sets in, by passing the vapour-air mixtures into tubes heated up to definite temperatures within an electric furnace. There would be a catalytic surface action in these experiments; that influence they hoped to eliminate by working with tubes of various dimensions. They evacuate the tube (of glass, mostly), turn the three-way cock on the vapour reservoir, and let the vapour enter the evacuated tube through a "lead" of glass tubing; the observer, behind a glass shield, watches whether or not ignition takes place, quietly or explosively. The leads used were of different lengths and diameters. When a lead of 1 mm. diameter gave ignition (or sub-ignition) at 200 deg., as they expected, a lead of 5 mm. caused ignition at 50 deg. or 60 deg. already; using a cock of 15 mm. bore, and a lead of 19 mm., 80 cm. long, they observed ignition at once when they suddenly opened the cock, at 16·5 deg. Thus the mere shock of the stopping of the vapour seemed to cause ignition, and they hence speak of this method of ignition as "shock ignition." They do not mention the possibility of electric sparking by the friction within the cock, and their experiments on securing more normal ignition conditions by shortening the leads and particularly by letting the sealed end of the tube project from the furnace support their explanation. With tubes from 2 cm. to 5·5 cm. wide, 100 cm. or more in length, the ignition always started well within the furnace. As regards the ether concentration they found that, as the ether increased from 1 per cent. to 2 per cent., the ignition temperature dropped rapidly from 480 deg. to 200 deg. and lower. Alcohol-air mixtures ignited at 500 deg. or less, in the presence of 1 per cent. of ether already at 255 deg. and below. Acetone-air mixtures also ignited about 500 deg. and proved much less dangerous than ether vapour. The further presence in the liquids of some glyceryltrinitrate (nitroglycerin) did not affect these temperatures notably, but the presence of any peroxides proved very dangerous. When the glass tubes were lined with metal tubes, the explosions became fiercer, though the ignition temperatures were little changed—at least in the first tests; the metals were rapidly attacked. It is interesting to add that sparks of steel to steel and of emery or pyrites to steel did not ignite the vapours, whilst ferrocerium-steel sparks did. So much is clear that ether vapours in particular are always dangerous.

### Gravity and Terrestrial Rotation.

Owing to the rotation of the Earth a body should apparently lose in weight when itself moving towards the east, in the sense of the rotation of the Earth, because the centrifugal force is increased, and gain in weight when moving towards the west. When O. Hecker, then of Strassburg, first attempted, in 1901, to verify this influence of the terrestrial rotation on gravity by observations on board ship when cruising in the Atlantic, he was mainly looking for other effects, changes of gravity with the depth of the sea, and his observations were inconclusive, and so were further cruisings in 1905 in the Indian Ocean and in the Pacific. But in 1908 Hecker was enabled, by the Russian Government, to steam east and west over the same track of the Black Sea, at speeds giving a differential velocity of 45 km. per hour, and the observations then were in fair agreement with theory. In his report upon Gravity at Sea, presented to the British Association last year,* Dr. Duffield pointed out that this influence would affect the barometers of ships in motion, and meteorological observations in general, and would still more affect the trajectories of shells and the carrying power of aircraft. In the *Annalen der Physik*, of September 4, 1919, Professor Roland Eötvös, of Budapest, shows that a man of 100 kg. weight should feel by 2 grammes lighter when

* See Engineering, October 17, 1919, page 520.

walking eastward at the rate of 1 m. per second, than when walking to the west. Now 100 kg. (about 16 stones) is a pretty heavy weight for a man, and the reduction of his weight by 1/10,000,000 would not much relieve him. The interesting point of the communication referred to is, however, that Eötvös—like Hecker a well-known authority on gravitation problems—has demonstrated the effect of the Earth's rotation on gravity in his laboratory. When a horizontal beam, loaded by weight at both of its ends, is turned about its axis, he points out, the two masses will alternately travel to the east and to the west, and the fluctuations in gravity will set up periodic vibrations in the beam which will increase and tend to a maximum in accordance with the theory of resonance of Helmholtz. The apparatus of Eötvös is a short loaded beam turned about a vertical shaft by a clockwork. On the shaft is mounted a small horizontal mirror, which should strictly be in the same vertical with the lamp above and the small hole of the diaphragm through which the ray from the lamp falls on the mirror. This ray is reflected upward and reflected again by a silvered glass, at 45 deg. to the vertical, and thrown on a vertical screen. The whole must, of course, be mounted to avoid all vibrations, and the clockwork must be very perfect; as regards the latter point Eötvös mentions that his excellent clockwork had been made at Cambridge for an astronomical telescope. If the apparatus were perfectly centred the light spot should describe a complete circle on the screen for each half a circle described by the rotating beam, the successive light-spot circles all coinciding. As a matter of fact absolute centring is almost impossible, and the two circles, corresponding to a complete rotation of the beam, turn into elliptical curves of unequal axes, having only one point in common, the one enclosing the other. The maximum amplitude of the vibrations looked for is deduced from the axes. Eötvös does not give observational data. Illness has prevented a continuation of his experiments, and he publishes his brief, mainly theoretical account, also because Dr. D. Korda, who had seen his only demonstration before the Budapest Physical Society in 1917 and had repeated it at Geneva, had recently published a paper on "Relations between the Experiments of Eötvös and of Foucault," "the aim of which I do not quite understand," remarks Eötvös.

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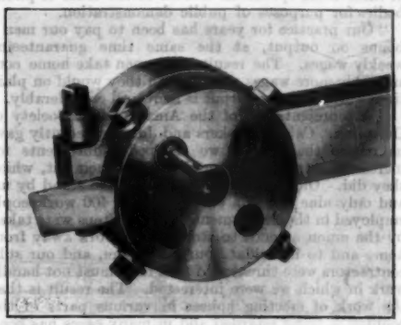
SWISS ELECTROCHEMICAL INDUSTRIES IN 1918.—Though the general difficulties increased in Switzerland during the last year of the great war, as they did elsewhere, the electrochemical and electrometallurgical industries of Switzerland quite held their own in that year. The production of calcium carbide increased from 72,000 tons in 1917 to 95,000 tons in 1918, and the increase would have been greater still if it had not been for the dearth of raw materials and of labour. The country itself only consumed about 7,000 tons of the carbide, there being a further development in the utilisation of acetylene for enriching coal gas and for working automobile engines. Most of the carbide was exported, and the chief buyer was again, as throughout the war, Germany; the exports of calcium carbide from Switzerland to Germany amounted in the years 1914, 1915, 1916, 1917, 1918, to: 29,580, 46,630, 46,260, 37,840, 44,210 tons. For France, the second country concerned, the figures for the years 1915, 1916, 1917, 1918, were: 10 tons, 10,360 tons, 17,110 tons, 29,870 tons. Austria, which had bought 3,940 tons of carbide in 1917, dropped out in 1918; previously it had, like France, manufactured all its own carbide. Most of the Swiss carbide works were fully occupied, and that may also be said of most of the cyanamide works which produced about 10,000 tons of cyanamide in 1918; the demand for cyanamide, however, was diminishing. The production of aluminium was 15,000 tons, a little larger than that of 1917; the home consumption of aluminium was 2,750 tons and about 80 per cent. of the aluminium was exported; the exports had, since 1916, changed very little, amounting to 11,570 tons in 1918. Of ferro-alloys, ferro-silicon did best, the production being 22,000 tons; the other alloys suffered from the scarcity of chromium, tungsten and manganese. In iron foundries electric furnaces made noteworthy progress; the important firms (Messrs. Sulzer, Roll, Fischer and others) entirely rely upon their own electric steel furnaces, which have likewise been introduced in smaller works. The production of caustic soda and chlorine was about the same as that of the preceding year, and the works at Monthey, Turgi and Schweizerhalle were again not quite able to satisfy the home demands; figures have not been published. Nitric acid from atmospheric nitrogen is being made at Chippis and at Bodio; the latter plant now draws additional power from the Ritom Lake. Further particulars will be found in the Report for 1918 published by the Swiss Handels und Industrie Verein, Zurich, both in French and German, at 9 francs.

## A MULTIPLE TOOL HOLDER.

AN ingenious and simple form of multiple tool holder, which is being placed on the market by the Newland Engineering Syndicate, Limited, of 1, Gresham Buildings, London, E.C. 2, is illustrated below. The tool holder is intended for use on lathes and similar machines using the ordinary form of forged tool. The holder, as will be seen, consists of a shank carrying at its outer end a rotatable disc or turret. In this disc eight circular holes are formed for the reception of the tool shanks. Four of the holes are formed on the circular perimeter of the disc and four on its face, and set screws are provided for clamping the tools in position. The main shank of the holder is formed into a split ring, or strap, which is bored out to suit the smaller diameter of the disc, and a clamping screw enables the strap to be tightened down on to the disc, so that the latter can be clamped in any position.



It will be evident that the Newland tool holder gives to an ordinary engine lathe many of the features of a capstan lathe. For repetition work of a small type and involving a fair number of tool changes the holder is particularly suitable. A roughing tool, two forming tools and a parting-off tool can be carried in the circumferential holes, and fairly complicated work can be formed from the bar without tool change, much as in capstan work. In use the various tools are brought into the cutting position by slacking off the clamping screw of the strap and moving the tool-carrying disc round by hand. The holes in the face of the disc enable four further tools to be carried, which can be used for boring and inside work, when the tool holder is mounted in the lathe as shown in the figure. If desired, of course, it can be mounted at right angles to the position shown, and the rotatable disc used as a small turret. An advantage of the holder is that the tools are small, economising tool steel, and can be simply made from round stock. A useful practical point is that the holes in which the tools fit are carried right through the disc, so that the shank of a broken tool which might tend to stick can be knocked out from the back end without trouble. The holder is simple and cheap, and should fill a useful place in shops in which the amount of repetition work does not justify the installation of capstan lathes.

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THE THEORY OF THE MICHELL THRUST BLOCK; ERRATUM.—In column 1 of the table on page 234 of our last issue the entry $\frac{6}{\pi}$ should read $\frac{0.6}{\pi}$. On the same page on the last line of column $\frac{6\lambda U}{ch}$ should read $-6\lambda U c$.

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MESSRS. HERBERT MORRIS, LIMITED, AND WAR WORK.—On the declaration of peace, Messrs. Herbert Morris, Limited, Loughborough, decided to present a number of specially-designed medals for presentation to those men recommended by the works manager as having put forth great efforts in the shops to serve their country. Altogether 165 medals—5 gold, 100 silver, and 50 bronze—were presented to the workmen last week end.

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BRIDGE-DESIGNING COMPETITION IN DENMARK.—The Department of Overseas Trade, 35, Old Queen-street, S.W. 1, have received a despatch from H.M. Commercial Secretary at Copenhagen, to the effect that a competition has been instituted by the municipal authorities of Aalborg in designs for a bridge which it is proposed to construct across the Limfjord between Aalborg and Norresundby. Photographs, together with maps, drawings and conditions of the competition may be inspected at the inquiry room of the department. This information is sent in view of the possibility of a contract arising from the competition, though it is understood that the actual building of the bridge may be postponed for some time owing to the difficulties of the present economic situation in Denmark. The Commercial Secretary places emphasis on the fact that the Danish scale of wages is very high, and this would have to be carefully borne in mind in any arrangements which it might be proposed to make.

## MARITIME WORK IN INDIA.

*The Restoration of a Cyclone-Damaged Breakwater End at Madras Harbour.**

*Coastal Sand Travel near Madras Harbour.**

By Sir FRANCIS JOSEPH EDWARD SPRING, K.C.I.E., M.A.I., M.Inst.C.E.

THE first paper is presented in fulfilment of the promise made by the author in his account of "The West Quay of Madras Harbour," printed in vol. cevi of the "Proceedings of the Institution."

In it the author describes the cyclone in question, with interesting evidence in regard to its wind effects elsewhere than at Madras and of its wave effects at Madras, and puts forward a theory that exceptionally heavy waves are less apt to be generated when a cyclonic storm passes steadily along its path than when it halts, or its forward movement is retarded. For in this case time is afforded to the cyclonic swirl to raise exceptionally heavy seas at the place of halt—seas which in due course extend circumferentially around the halting place as a centre.

He describes the damage done by the waves generated by the exceptionally heavy cyclone in question—that of November 22 and 23, 1916—waves such as are seldom experienced in the Indian Ocean more than three or four times in a century. The paper points to the weakness of the original design, and indicates how it was decided not to leave this particular kind of weakness in the reconstructed work. It goes on to explain how, for the intended reconstruction work, certain steel was expected from England, and that it was not until just a year after the accident that it became manifest that, owing to war exigencies, the steel could not be supplied, and how, in consequence, a hasty decision had to be come to as to the design of what the author, following motorists' analogy, describes as a "roadside repair."

The paper tells how a new blockyard was formed and how some 1,600 20-ton to 33-ton blocks were made, a large proportion of them being of special design. It tells how, under grave difficulties in the matter of plant and supplies of most kinds, a rubble base was deposited in a deep and extensive hole dredged in the sea bed, and how, on this as a base, the "semi-permanent head," as the work described in the paper has been designated locally, has been erected, ready in due course to form the stand, or jumping-off place, from which operations will proceed on the permanent repair work—a sunk well caisson—to be undertaken when conditions permit of the despatch from England of the delayed steel. From first to last the work will have cost the Madras Port Authority 118,000*l.*, or for the "roadside repair" alone, and all that led up to it, about 75,000*l.*

In the second paper the author submits two plans showing the 5-fathom and 6-fathom contours at Madras Harbour in the years 1910 to 1919, thus extending plans shown in an earlier paper, for 1910–13, to a period of ten years. From these contours the author draws the conclusion that the sand from the south is undoubtedly creeping up steadily at the rate of about 1,000,000 tons per annum, and that it is only a matter of time before the harbour authority will have to deal with the trouble at the entrance in one way or another. Either the sand along the south beach will have to be moved away by rail and used for such purposes as land reclamation; or a dredger must be used either to pump sand ashore or to deposit it at sea; or another breakwater must be run out to oppose the sand stream.

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SWEDISH SHIPPING.—The Transatlantic Shipping Company, of Gothenburg, which is one of Sweden's largest transoceanic shipping companies, has for some time been elaborating a programme for new building which aims at making its fleet the largest and best-equipped in Scandinavia, says *Swedish Export*. For this purpose the company has successively sold most of its vessels under 4,000 tons and has ordered in their place new and up-to-date vessels. During the years 1920–21 Swedish and British shipyards are to deliver 73,600 tons deadweight, after which the total tonnage of the Transatlantic Company will amount to about 265,000 tons deadweight. Of the new vessels, 45,000 tons are to be motor vessels with Diesel engines or using oil burners.

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TRINITROTOLUENE POISONING.—Like many other poisons T.N.T. is detrimental when taken directly, when inhaled as dust and when entering the system through the skin. According to a report by Voegtlin, Hooper and Johnson, of the United States Hygienic Service, dogs and cats are as susceptible to the poison as human beings; while rats, rabbits and guinea pigs suffer less. Dogs fed on meat seem to be able to resist better than dogs kept on a bread-milk diet. For men in works a skin protection has been found in a varnish of shellac, castor oil, alcohol (95 per cent.), mixed in proportions of 1 : 1 : 24; the film dries without peeling off and can be removed with the aid of alcohol. Cotton gloves impregnated with this varnish (somewhat modified) are said also to afford good protection. When the skin has become contaminated with T.N.T., the poison can, according to Dr. Alice Hamilton, be extracted by washing with a 10 per cent. of sodium hydrosulphite or also of sodium sulphite. Some men have been found to be particularly sensitive to T.N.T. poisoning. As regards the introduction of remedies through the skin, the American investigators are doubtful. A reduction of hæmoglobin is early noticed in the cases of T.N.T. poisoning, and a blood test is hence recommended for workers. Special gas masks are also recommended.

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* Abstracts of papers read at the Institution of Civil Engineers, on Tuesday, February 24, 1920.

## INDUSTRIAL NOTES.

The Ministry of Labour reports that the engineering trades, and to a smaller extent the iron and steel and some other branches of the metal trades, continued to be affected by the strike in the iron foundries throughout January, and though the settlement of the dispute resulted in an improvement in the state of employment, normal conditions had not been restored at the end of the month. In nearly all other trades employment was good or fairly good in January and little disturbed by disputes. The general level of retail prices of food and other items (including rent) of working-class family expenditure at February 2, 1920, calculated on the basis of the pre-war standard of consumption, was about 130 per cent. above the pre-war level, as compared with 125 per cent. a month earlier. Trade unions with a net membership of 1,564,066, reported 2·9 per cent. of their members as unemployed at the end of January, as compared with 3·2 per cent. a month earlier, and 2·4 per cent. at the end of January, 1919. In industries in which workpeople are insured against unemployment under the National Insurance Acts, the percentage unemployed on January 30, including demobilised members of H.M. Forces claiming out-of-work donation, was 6·10. The corresponding percentage for January 2, 1920, was 6·58. Omitting the engineering and iron-founding trades, the percentage unemployed on January 30 was only 4·21. The total number of ex-service men and women claiming out-of-work donation on January 30 was 377,116, as compared with 383,095 on January 2. The number of men on the live registers of the Employment Exchanges, on the 6th inst., was 443,085, or a decrease of 60,573 on January 2; and the number of women was 51,899, or an increase of 5,036 on the total of January 2. The number of vacancies unfilled on the 6th inst. was 28,900 for men and 46,967 for women, the corresponding figures for January 2 being 25,979 and 46,002. Employment at coal mines in January continued good; the number of workpeople employed and the number of days worked by the miners was about the same as a month earlier. Compared with January, 1919, there was an increase of 13 per cent. in the number employed and also an improvement in the number of days worked, which, in January, 1919, was reduced by disputes. At iron and shale mines employment continued good; at tin mines it was fair, while at lead and zinc mines there was much variation as between different districts. At quarries employment remained good generally. In the pig-iron industry employment continued good and there was a net increase of 13 in the number of furnaces in blast, though the total was still 30 below that of a year ago. Employment at iron and steel works was fairly good, though affected by the strike at iron foundries. This strike had a much more serious effect in the engineering trades, in which there was a great deal of unemployment and short time. In the shipbuilding trade employment was fair on the whole, and in the tin-plate trade it was good. In most of the other metal trades also employment was good. In the cotton trade employment continued fairly good in the spinning section and good in the weaving section. Employment was fairly good in most of the building trades; with bricklayers and carpenters it was very good, men being scarce in many districts. In the woodworking and furnishing, brick, cement, pottery and glass, paper and printing, and food preparation trades employment continued good. Changes in rates of wages reported to the department as having been arranged to come into operation in January, with effect from that month, or from earlier dates, resulted in a net increase of over 280,000*l.* in the weekly wages of nearly 1,100,000 workpeople. The principal changes affected railway servants, workpeople employed in gas undertakings, iron-founders, and building and printing trade operatives. Changes in hours of labour arranged during January affected 16,000 workpeople, whose hours were reduced by an average of about 4½ per week.

The number of trade disputes beginning in January was 86, and the total number of workpeople involved in all disputes, new or old, was about 119,000, as compared with about 105,000 in the previous month, and about 460,000 in January, 1919. The estimated aggregate duration of all trade disputes during the month was 1,793,000 days, as compared with 1,688,000 days in December, 1919, and 2,918,000 days in January, 1919. Of the total number of workpeople affected by these disputes, more than half were involved, either directly or indirectly, in the strike in the iron foundry industry, which began in September, 1919, in support of a claim for an advance in wages, and which terminated during January.

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A letter to the editor by Messrs. Boulton and Paul, Limited, in *The Times* of the 19th inst., reads as follows:—

"The Prime Minister pointed out to representatives of local authorities at the conference at 10, Downing-street the very serious difficulties trade unions were placing in the way of cottage building, by their rules and regulations, and clearly intimated they must be held largely responsible if the requisite houses are not built. The difficulties referred to are very real and determined, and we feel they are not fully appreciated by the public.

"For the past thirty years we have made a speciality of building permanent wooden houses. When we ceased our war activities we reorganised our workshops to cope with mass production of cottages for rural districts to approved plans and specifications of the Ministry of Health. This was followed by extensive advertising, with the result that we have contracted to build cottages all over the country. We had confidence that if we had the hearty co-operation of labour we could build at the rate of 2,000 cottages per annum. At the moment we have contracted to build cottages in over 100 places in this country, many of these being specimens erected to the order of public bodies for purposes of public demonstration.

"Our practice for years has been to pay our men a bonus on output, at the same time guaranteeing weekly wages. The result is our men take home considerably more wages weekly than they would on plain time work, and our output is increased considerably.

"A representative of the Amalgamated Society of Carpenters, Cabinet Makers and Joiners, recently gave us notice that unless we stopped inducements for increased output they would call our men out, which they did. Our men, however, decided to stand by us, and only nine out of a total of about 400 workpeople employed in the department left us. Steps were taken by the union at once to stop all our work away from home and to intimidate our customers, and our sub-contractors were threatened that they must not handle work in which we were interested. The result is that the work of erecting houses in various parts of the country is being retarded and in many cases has been brought to a standstill. The unions further object to carpenters fixing asbestos slates, which our men have always done, and contend that this is slaters' work, well knowing there are not sufficient slaters available for the work, irrespective of the increased and unnecessary cost which would be entailed.

"We think it desirable that the public should know the extent to which trade union restrictions are delaying the erection of the houses which are so urgently required throughout the country."

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At the sitting of Parliament on the 18th inst., Captain Hambro called attention to the action of certain trade unions in restricting the employment of discharged soldiers and sailors. In the course of the debate, Colonel Ashley said the majority of trade unions had behaved well; but the bricklayers' union and those connected with the carpentering trade, had passively resisted the claims of ex-service men, whilst the Amalgamated Society of Engineers had actively done all that they could to stop ex-service men from obtaining employment. In order to meet the objections of that society, the Government had modified their proposal in regard to the training of disabled men so that it related to only 1,750 men, or one-third of 1 per cent. of the membership of the society; but the society absolutely turned down the scheme. Mr. A. Hopkinson, who is an employer of labour, gave his experience as to the uncompromising attitude of the trade unions, and said Trade Unionism would not flourish if it had a heart of stone, as for the Labour Party, it was a pathetic collection of contented hypocrites and broken-hearted saints. The party had never had any ideals; it did not even know what ideals were. Sir R. Horne, Minister of Labour, confirmed that the Amalgamated Society of Engineers and the Sheet Metal Workers refused to have anything to do with the training schemes. He asked members of the Labour Party to convert the unions in that matter. In regard to the employment of fit men they had the contrast that while there were nearly 400,000 ex-service men without any work, there was a shortage in the building trade of 200,000 men. He added that while a strike was going on at Horbury, the Government were asked by the Parliamentary Committee of the Trade Union Congress to start building wagons at Woolwich. They started, but the Union of Wagon Builders, in the teeth of everything that was said on the Labour benches, and in direct opposition to the proposal of the Trades Union Congress, declared that they would not agree to let the discharged men work at Horbury unless the Government stopped building wagons at Woolwich. The jealousy of the trade unions rose up against the Government's projects, and their best efforts were defeated.

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*The Labour News Service*, a publication issued from the headquarters of the Labour Party, referring to the recent discussion in Parliament on the question of employment of ex-service men, a brief abstract of which is given above, says it is misrepresentation to suggest that the trade unions are callous or indifferent to the claims of these men. It adds that a large number of trade unions have satisfactory schemes in operation for the training and employment of ex-soldiers, and that the charges made are bound to result to the disadvantage of the trade union movement and of the Labour Party. It may be possible, it further states, that more adequate arrangements could be made which, while permitting the employment of unskilled ex-service men would, at the same time, prevent a depreciation of the present status of the industrial workers. Perhaps the best course would be for the Parliamentary Committee of the Trades Union Congress to arrange a joint conference between the several trade unions concerned and the various ex-service men's organisations to inquire into the whole matter and to see what new schemes could be agreed upon to bring about a greater absorption of unskilled labour and at the same time provide adequate protection against any attempt on the part of employers to use the employment of ex-service men to the detriment of the present industrial standards.

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In the quarterly balance sheet to December 31, 1919, of the General Federation of Trade Unions, the secretary, Mr. W. A. Appleton, says that the total amount spent during that quarter was 154,542*l.*, of which sum 145,710*l.* was paid out in connection with two disputes, the cotton strike and the moulders' strike. The saddest thing about this expenditure, Mr. Appleton adds, is its failure to secure anything beyond what might have been secured by negotiation and without the strikes. Unfortunate as these figures appear, they still left the Federation, on December 31, with a nominal balance of 116,914*l.* During the quarter, attention has been called to the changed value of money and the desirability of increasing both contributions and benefits. The management committee is considering the suggestions made, which include the creation of differential scales of contributions and benefits, and the possibility of reinsuring all an affiliated organisation's strike or lock-out liabilities. The Federation comprises 132 affiliated societies, having a membership of 1,184,448 on which contributions are paid.

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The French journal *La Democratie Nouvelle* publishes a statement from Lausanne with reference to the working by the State of the former Austrian military establishments. At Vienna Arsenal, where the manufacture of furniture and carriages had been started, the expenditure in the shape of wages rose to 38,000,000 crowns and the receipts only amounted to 14,000,000 crowns. In another establishment which had been set apart for the manufacture of tools and the building of aeroplanes, the receipts amounted to 85,000 crowns and the expenditure to 4,500,000 crowns. Other establishments have given similar bad results.

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The experiment of the Government operating the railroads, says *The Iron Age*, New York, has been a costly one, but if it has shown the hopelessness of obtaining satisfactory results by anything except private ownership with Government supervision, it is worth all it has cost. There were many people in addition to labour union members who would have been glad to have the railroads remain under Government control two or three years longer in order finally and more thoroughly to test Government efficiency, but now that the railroads are about to go back to their owners, it would be surprising if there were any important agitation for many years to come in favour of the Government resuming control to the extent which has prevailed during the war period, or of acquiring ownership. Government operation has not been wholly bad, and some of the policies inaugurated will not be abandoned, but for the most part the superiority of private ownership under competitive conditions has been demonstrated.

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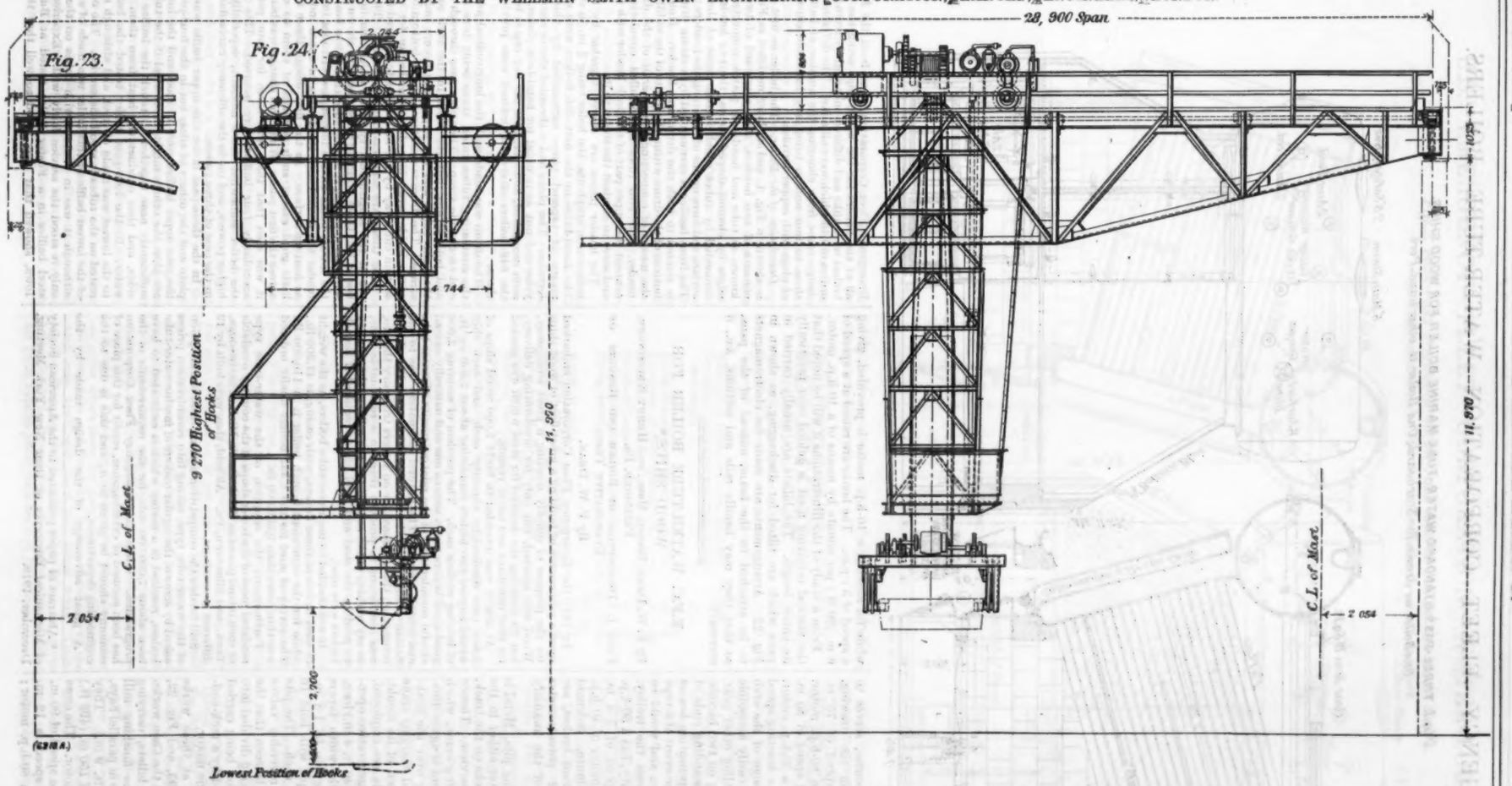
Mr. T. Richards, M.P., secretary of the South Wales Miners' Federation, addressing his constituents at Ebbw Vale on Monday last, said the working class needed talking to. They were beginning to "boss the show" and to "boss" everyone. The growth in their power was a temptation to resort to might; but the country was in a very dangerous situation, and he appealed to workers to be careful how they used their power. War-time pacifists were now advocating "direct action" and heading the country for revolution. During the war, these men could not shed the blood of a German, but to-day they seemed prepared to foster bloodshed amongst men of their own kith and kin. It seemed as though others had come back from the battle front with the German ideal that might was right. The British working man, he added, had more freedom than any subject under the sun, and he warned his audience against following a will-o'-the-wisp which would put progress back a hundred years.

# BILLET HANDLING CRANE AT THE WORKS OF THE SOCIÉTÉ NORMANDE DE MÉTALLURGIE, CAEN, FRANCE.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.




## MACHINERY AT THE STEEL WORKS OF THE SOCIÉTÉ NORMANDE DE MÉTALLURGIE, CAEN, FRANCE.

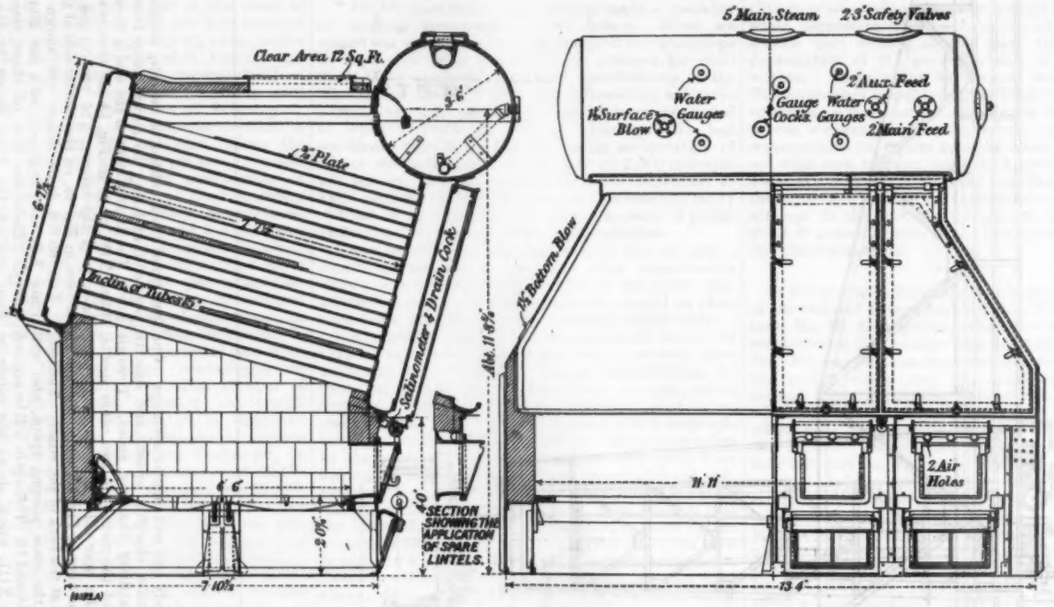
(*Concluded from page* 180.)

CONTINUING the description of this steel plant, we now give in Figs. 13 and 14, page 284, and on the present page and Plates XIII to XVI, illustrations of the metal mixer, ladle cranes, soaking pits, and billet-handling cranes, &c. Figs. 13 and 14, page 284, and Figs. 17 to 19, Plate XIV, show a 700-ton metal mixer, which is employed to store the hot metal coming from the blast furnaces and pass it on as required, to the converter plant. This mixer is of the circular type, designed to hold a depth of metal of 3·400 m. (11 ft. 2 in.). It is 27 ft. long inside and 15 ft. 10 in. in internal diameter. It is fired by blast-furnace gas, air preheated in a regenerator chamber being employed to promote combustion. The heat is required to balance radiation losses, and keep the metal in a suitably molten state for transference to the open-hearth furnaces. The mixer is made of shell plates, 1¼ in. thick, double butt strapped at the joints and stiffened throughout with girder section stiffeners. It is mounted on eight articulated rollers so that the load is evenly distributed. The mixer is tilted by means of two double-acting hydraulic cylinders working in pits. The cylinders are designed for a pressure of 700 lb. per square inch. The mounting and tilting gear will be seen in Fig. 18. Fig. 19, which gives a plan of the mixer to a smaller scale, shows at the right-hand end of the body two rectangular openings. One of these is the main charging spout, and exactly opposite is an auxiliary charging spout. Towards the left-hand end of the mixer are two other spouts. The smaller, on the near side, is a slagging spout. This is shown in the view in Fig. 13, which is taken on the upper platform at the back of the mixer. The long spout opposite is the main pouring spout, also well shown in Figs. 14, 18 and 19. This again will be noticed in Fig. 15. Plate XIII, which shows the mixer in relation to the rest of the plant. Incidentally, some idea of the size of the mixer may be gathered from the figure of a man shown in this view standing below the stairway leading to the upper platform. All these spouts are fitted with covers to retain the heat, as shown in Figs. 13 and 18. The top of the vertical gas uptake is mounted on wheels, forming a movable port end, and may be moved away from the mixer inlet. The arrangement of the seal is shown in Fig. 17, Plate XIV, while in Fig. 13 the head is shown drawn back from the mixer. The vertical gas uptake may be seen in Fig. 14, on the further side of the mixer.

Two 60-ton ladle cranes are shown in Fig. 20, Plate XV, each equipped with one 20-ton auxiliary trolley. There are five of these cranes installed. Four are of the type shown in the lower part of Fig. 20 and again in Figs. 15 and 16, Plate XIII, these being employed for casting, while one of the type shown in the upper portion of Fig. 20 is used to carry the hot metal from the mixer to the Thomas converters. The lower crane is fitted with guides to the lifting gear, in the form of a long hanging

# U.S. EMERGENCY FLEET CORPORATION WATER-TUBE BOILERS.

*Fig. 1.* THREE-PASS STANDARD WATER-TUBE MARINE BOILER FOR WOOD SHIPS.
*One Boiler as drawn for Starboard; One Boiler to other hand, Port*




frame fixed to the crab. This, of course, serves to steady the ladle, as will be seen in the drawing. These cranes have a longitudinal speed of 75 m. (246 ft.) per minute, obtained from a 80-h.p. motor. The main crab has a cross-traversing speed of 30 m. (98 ft.) per minute. This is given by a 20-h.p. motor. The hoisting motor is 80 h.p., giving a hoisting speed of 4 m. (13 ft.) per minute. The design of the crab or trolley is open, and all shafts are easily accessible and can be removed without dismantling other gear. The load is taken on 16 ropes winding on two barrels. There are four separate ropes. The standing ends of two on each side are attached to compensating beams which have a movement of 1 in. In the event of a rope breaking, the load can only fall ¼ in., and would be carried by two ropes diagonally across the trolley. The auxiliary trolley, of 20 tons capacity, has a 50-h.p. hoisting motor, giving a hoisting speed of 7·3 m. (24 ft.) per minute, and a traversing motor of 10 h.p. giving a speed of 44 m. (14½ ft.) per minute. Solenoid brakes on the motor, and Weston load brakes, are provided on the main hoist, and potentiometer resistance control for the lowering of the auxiliary hoist.

Fig. 16, Plate XIII, shows the casting pits. Metal is poured into the moulds with the latter either in the pits or standing on small platform trucks on the track, as may be seen in the distance of this view. Thence the ingots are taken off to the stripping crane, which was shown in Fig. 5 (Plate X *ante*), and is again illustrated in Fig. 21, Plate XVI, working over the soaking pits. This combined stripping and charging crane is there seen placing an ingot, stripped of its mould, in the soaking pit. Two of these pits are employed. They are of the producer gas-fired regenerative open-cell type. The pits cells are 12·2 m. (40 ft. 4 in.) long, and 2·3 m. (7 ft. 6½ in.) deep, while the width tapers from 2·1 m. (6 ft. 10½ in.) at the top to 1·8 m. (6 ft. 11 in.) at the bottom. Each pit will hold 16 ingots of a maximum size of 5 tons each. The pits are controlled by 24-in. Forter gas reversing valves and 33-in. butterfly valves. It will be seen that the pit covers are of the rolling pattern, being divided into five sections for each pit, each section being carried by four small wheels. They are moved by a rack-and-pinion drive geared to a 30-h.p. electric motor.

Another of the interesting cranes at these works is shown in Figs. 23 and 24, page 293, and Fig. 22, Plate XVI. There are two of these at the Caen works. They are intended for handling hot billets, carrying them from the blooming mill to the finishing mill reheating furnaces. The cranes operate in parallel bays, and each has a span of 28·9 m. (94 ft. 9 in.). They have a longitudinal travel of a speed of 150 m. (492 ft.) per minute, obtained from an 80-h.p. motor. The cross traverse is by a 20-h.p. motor, giving a speed of 90 m. (286 ft.) per minute. The hoisting speed is 12 m. (39 ft.) per minute, obtained with an 80-h.p. motor; while for slewing, a 10-h.p. motor is provided, giving a speed of 3 r.p.m. The hooks are raised at a speed of 6 m. (20 ft.) per minute by means of a 10-h.p. motor.

From a study of the illustrations it will be noted that the vertical revolving mast is guided over practically its entire length. The billets are usually carried in pans which are tilted for discharging, as shown in Fig. 22. Arrangements are made for electromagnets to be attached to the beam, instead of the pans, so that they may handle rails and sections, &c., if necessary.

## E.F.C. WATER-TUBE BOILER FOR WOOD SHIPS.*

By F. W. Dean, Boston, Mass., and Henry Kreisinger, Pittsburgh, Pa.

Part I. Description of Boiler and Results of Evaporative Tests.

By F. W. Dean.

In 1917 the Emergency Fleet Corporation embarked upon a programme of building a great fleet of wood ships for the purpose of quickly meeting a great emergency. Wood was selected, not only for accelerating delivery, but for reducing the demand for steel which was needed for steel merchant and naval vessels.

At first it was intended to build 1,000 wood ships of 3,500 tons deadweight capacity each, and each ship would require two boilers containing about 2,500 sq. ft. of heating surface each. The problem of securing 2,000 good-sized boilers was a serious one and naturally caused careful consideration of the relative merits of water-tube and Scotch boilers. The natural inclination was to use Scotch boilers, but the boiler-making capacity of the country on the sea coast, or on waters tributary thereto, was insufficient to produce them in a reasonable time, to say nothing of the capacity of the mills of the country to produce the steel and steel plates required if Scotch boilers were used.

It was decided to use water-tube boilers, as the weight of steel in one of these boilers, with casing, is 41,200 lb., while for the equivalent Scotch boiler it is 110,000 lb. The saving of steel for the 1,352 boilers finally ordered was thus more than 9,000,000 lb.

Furthermore, the adoption of the water-tube type rendered most of the boiler shops of the country available at such inland places as Battle Creek, Mich., Chattanooga, Tenn., and Allentown, Pa. All told, they were built by 19 different contractors.

Still further the competition coming from the adoption of the water-tube type, taking into consideration prices asked by some of the regular makers of marine water-tube boilers, resulted in a saving which is estimated to have been about 7,000,000 dols. for the requirements of the programme. While the Emergency Fleet Corporation has been accused of extravagance, credit for this piece of economy should be given to it, and this is due to the engineering department.

A great advantage of the design made by the Emergency Fleet Corporation came from the fact that all of the boilers for the wood ships using the first 706 boilers were alike and differed only slightly from the later orders of 646 which were all alike. The differences in the design came from changing the number of baffles from three to four and in using key handhole caps instead of plugs with copper ferrules.

*Description of the Boiler.*—The boiler as first designed is shown in Fig. 1, and as later modified in Fig. 2. It consists of two headers, each composed of two plates, known as tube and hand-hole plates, connected at the edges by channel-shaped pieces, the two headers being connected by tubes which furnish most of the heating surface and form means of fastening the headers together. The front header is surmounted by a steam drum which is riveted to both the drum and header. Holes in the bottom of the drum within the limits of the saddle furnish the means of connecting the interior of the drum and header, and two rows of so-called circulating tubes connect the upper part of the back header with the drum and serve to conduct the steam to it.

The header plates are stayed together by means of hollow iron staybolts, the holes being ¾ in. in diameter. The hand-holes in the first 706 boilers were closed by means of tapered plugs surrounded by thin copper ferrules. The plugs had a threaded shank secured by a yoke and nut as is usual for hand-hole plates. It was soon recognised, however, that the key cap is better and the 646 boilers afterward ordered were provided with them.

The drum was made with the longitudinal joint where the circulating tubes enter, there being here an inside and an outside strap. The tubes pass through the shell and both straps, but the holes in the shell are larger than the tubes and the expanding occurs only in the straps. The drum is reinforced at the bottom by means of an inside strap in order to make up for the plate section cut away by the holes already referred to.

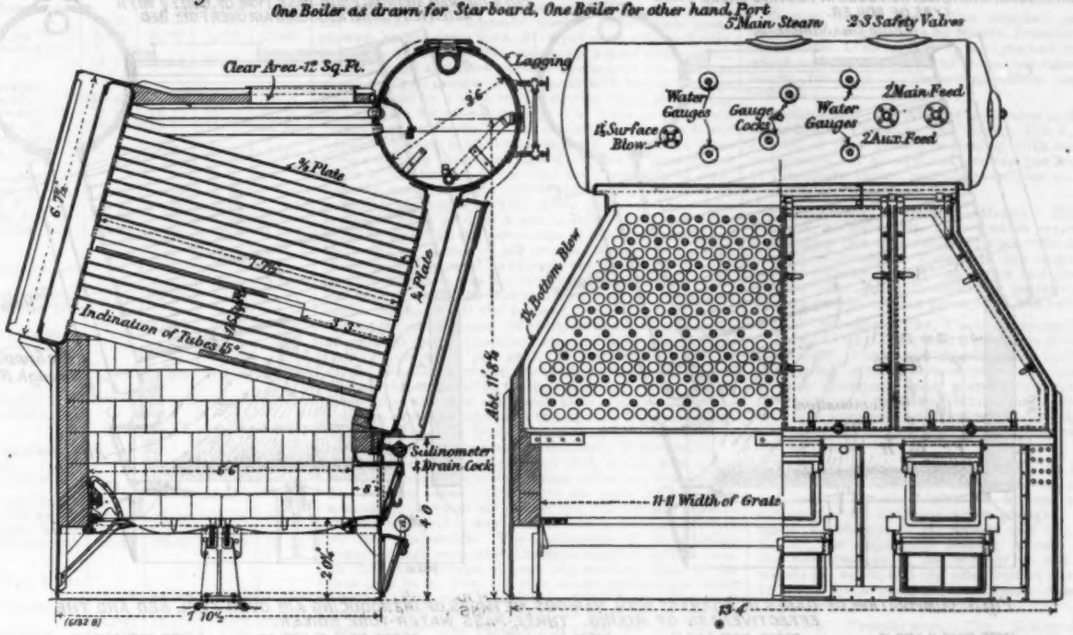
The tubes are seamless hot-rolled steel. The baffles are of the longitudinal type, of which the first boiler tested had three, forming three passes as shown in Fig. 1. After some testing it was decided that it was best to place the lowest baffle on the lowest row of tubes in order to render the second and third rows of tubes more active as heating surface. In the first design these tubes did little good except such portions of them as extended across the first pass. When this change was being made it was seen that there was room for four passes, and accordingly four baffles were inserted. This rendered the boiler somewhat more efficient, especially at the higher powers, and made the efficiency curve flatter than in the case of three passes.

In the three-pass boiler the upper baffle was of steel plate and the others of tiles, but in the four-pass boiler the two upper baffles were of steel and the indications are that the others might be of steel if the tubes were sufficiently near together to touch the baffles on both sides, and thus conduct the heat from them into the water. In the four-pass boiler tested the baffle next to the lowest was made of steel, and although it merely rested on the tubes it stood the service. The outer end of the lowest baffle of this boiler was made of steel, and although it was in contact with tubes on the bottom only it stood the service fairly well. Experience with steel baffles in a Foster boiler tested at Burlington, Iowa, showed that they stood so well that they were

* Abstract of paper presented to the American Society of Mechanical Engineers at their New York Meeting, December, 1919.

# U.S. EMERGENCY FLEET CORPORATION WATER-TUBE BOILERS.

*Fig. 2.* FOUR-PASS STANDARD WATER-TUBE MARINE BOILER FOR WOOD SHIPS.
*One Boiler as drawn for Starboard, One Boiler for other hand, Port*




adopted in all positions in this boiler. By using steel baffles in the four-pass boiler, 34 more tubes can be put in. The four-pass boiler is shown in Fig. 2.

In the drum of the standard boiler there is the usual deflector plate which prevents the steam, as it comes through the circulating tubes, from passing across the drum and compels it to pass to the ends. This deflector was removed for a time and no difference in the behaviour of the boiler could be observed except that the water as it appeared in the glasses was livelier. In a seaway other advantages might occur.

In the top of the drum a perforated dry pipe is used, having eighty-eight ¾-in. holes. This is a rather small area, and it proved to have an important effect in separating moisture from the steam. This was determined by testing the boiler both with and without the dry pipe. The reduction in the pressure of the steam in passing from the drum to the steam nozzle was determined by a mercury manometer. At ordinary rates of working the loss in pressure amounted to little, but when forcing it amounted occasionally for short periods to 6 in. or 8 in. of mercury.

The casing of the boiler is built up of steel plates joined together by external and internal shapes secured to a channel frame at the bottom which rests on the keelson of the ship. At the front there are two vertical channels acting as columns which are secured to the channels and bolted to tees riveted to the bottom of the header. The rear header of the boiler rests on a shelf formed in the casing, and the casing is a close fit around the rear header. The front columns form the only rigid connection to the channel base, and the boiler is free to slide in the rear part of the casing. The channel base is bolted to the bottom of the ship and the casing holds the boiler firmly in place, and is amply able to prevent rolling or pitching at sea or in a collision, all of which has been proved by experience, including the latter, even without rolling or collision braces.

The front and back of the casing have sheet-iron doors covering the headers, and the space between the headers and doors is sufficiently great to accommodate soot blowers. These blowers, which are found to be of great importance, blow through the hollow staybolts.

The boilers are equipped with bottom and surface blows, a duplex safety valve, two water glasses, a set of three-gauge cocks, main and auxiliary feeds, a salinometer cock, a basket of zinc plates and an internal perforated feed pipe.

In the three-pass boiler there are four fire doors and four ash-pit doors, but in the four-pass boiler there are three of each. These doors are of the in-swinging type. Above each door there is a hollow perforated lintel with air freely entering through holes in the casing and on the sides of the doors there are perforated jambs with air supplies from the outside. All of these air openings are not only useful in protecting the parts from burning, but promote economy, for it is found that none too much air enters the furnace through them.

The grates are of the fixed type of double bars in two lengths, and have ½-in. air and ½-in. iron spaces.

Across the back end of the furnace there is a cast-iron bridge wall with narrow air spaces which saved nearly 2 per cent. of coal, perceptibly diminished smoke, improved the gas analyses, saved the back brickwork and reduced the time and labour of cleaning the fires nearly 50 per cent.

*Dimensions of Boiler.*—The following are the leading dimensions of the boiler :—

| | Ft. | In. |
|---|---|---|
| Width of casing at floor level ... | 13 | 4 |
| Length of casing at floor level ... | 7 | 10½ |
| Height of centre of drum above floor | 11 | 8½ |
| Thickness of header plates ... ... | 0 | 0½ |
| Width of water spaces of headers ... | 0 | 8 |
| Outside diameter of tubes ... ... | 0 | 3 |
| Exposed length of tubes between headers ... ... ... ... | 7 | 7½ |
| Number of tubes between headers... | 388. | |
| Number of tubes between rear header and drum ... ... ... ... | 21. | |
| | Ft. | In. |
| Inside diameter of drum ... ... | 3 | 6 |
| Thickness of drum plates ... ... | 0 | 0½ |
| Width of furnace ... ... ... | 12 | 0 |
| Depth of furnace ... ... ... | 6 | 6 |
| Height of furnace at centre... ... | 3 | 8 |
| Firing doors ... ... ... | 15 in. by 18 in. | |
| | Ft. | In. |
| Width of grate ... ... ... | 11 | 11 |
| Depth of grate without bridge wall | 6 | 6 |
| Depth of grate with bridge wall ... | 5 | 8 |
| Grate area without bridge wall | 77½ sq. ft. | |
| Grate area with bridge wall | 67½ sq. ft. | |
| Heating surface, fire sides ... | 2,518 sq. ft. | |
| Thickness of brick lining ... ... | 8½ in. | |

*The Evaporative Tests.*—In the beginning it was decided to use Georges Creek Cumberland coal, from the Big View vein on all tests, in order to have a standard coal of good and uniform quality, low volatile content, and high-fusing clinker.

It was also decided to make tests with fixed grates, shaking grates, fire-box without a bridge wall, with the iron bridge wall already mentioned, a brick bridge wall covering the same area as the other, and several kinds of oil burners, using Mexican oil. Mexican oil was selected because that is the oil that will be used chiefly in future.

The three-pass boiler was erected with the baffles in the positions and of the lengths in the original drawing, but the first test showed that they were not sufficiently long. Several of the earlier tests were made with the grate of the full size, that is to say, without the iron or the brick bridge wall. By the addition of the iron bridge wall, admitting air around the fire doors, lengthening and otherwise changing the baffles, and studying the method of firing, the efficiency of the three-pass boiler was raised from about 60 per cent. to about 71 per cent. based upon dry coal, and to about 73 per cent. based upon combustible. The efficiency of the four-pass boiler was about 72½ per cent. based on dry coal, and based upon combustible exceeded 74 per cent. on two tests. These tests were made when firing by hand, but when using the type "E" stoker higher efficiencies were obtained.

*Results of Tests.*—In the complete paper four tables are given which show the general results of the tests of the three-pass and four-pass boilers under all of the conditions, both with hand and stoker firing. Those for the four-pass boiler with stoker firing are given below in Table I, page 297. No results with oil firing are given because those tests are now in process.

While it was intended to test the boiler at the marine rating in general, which is to evaporate 6 lb. of water per square foot of heating surface per hour, other rates were used, especially with the four-pass boiler. In the test of December 18, 1918, the four-pass boiler (hand-fired) was worked at 131 per cent. of marine rating and 229 per cent. of land rating. Even at this high rate the efficiency was about 71 per cent., and but little below that of lower rates. With the stokers the boiler was operated at 162 per cent. of marine rating and 282 per cent of land rating. At this rate the evaporation was 9·72 lb. per square foot of heating surface per hour from and at 212 deg., and the efficiency was 72·3 per cent. based upon combustible. Based upon the total area of grate for hand firing the coal consumption was at the rate of 29·6 lb. per square foot of grate per hour. The coal consumption per square foot of heating surface per hour on this test was 0·92 lb. The test of April 8 (Table I), shows a very high efficiency, but this is open to suspicion because the heat balance did not work out quite properly, due, it is thought, to an error in the coal weight of 1 hour. All of the tests given in Table I, were of 24 hours duration each, excepting that of April 13, which was for 22 hours.

The conclusion arrived at is that the boiler is of excellent efficiency, and that the four-pass boiler is well adapted to overloads. This is due to its having four passes. The only defect of the four-pass boiler is, as might be expected, that there is considerable absorption of draught in the passes, and the greatest loss was in the third pass from the bottom. The third baffle was lowered one tube, but the great loss continued, and it was then restored to its former position.

Among the experiments tried with this boiler were those to determine whether the number of circulating tubes and the number of holes in the bottom of the drum connecting its water space to that of the front header were excessive. Half of them, together and separately, were closed, but no effect could be observed. The conclusion was that an unnecessary number of such tubes and openings are used in this type of boiler, and by reducing them the drum will be made a safer structure.

The quality of the steam was most satisfactory when the water was carried at a proper level, and it was necessary to carry it near the top of the glass before the limit of a throttling calorimeter was reached. The quality of the steam is given in all of the tables.

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## PART II. PRELIMINARY TESTS.

By HENRY KREISINGER.

This part of the paper presents some of the results of special investigations conducted by the Fuel Section of the Bureau of Mines in connection with the tests of the three-pass and four-pass marine boilers shown in Figs. 1 and 2. Outline diagrams illustrating the methods of testing these boilers are given in Figs. 3 and 4. The special investigations consisted of the study of combustion in the furnaces and the temperature of gases as they flow through the boiler. This study was carried on by the analysis of samples of furnace gases collected at various points in the setting.

Fig. 3 is a diagram of the three-pass boiler as originally designed. After the first few tests the baffles were extended, making smaller the gas passages between the ends of the baffles and the water legs. Other changes were also made as the investigation indicated the need

# U.S. EMERGENCY FLEET CORPORATION WATER-TUBE BOILERS.

*Fig. 3.* DIAGRAM SHOWING METHOD USED IN TESTING THREE-PASS TYPE OF BOILER.

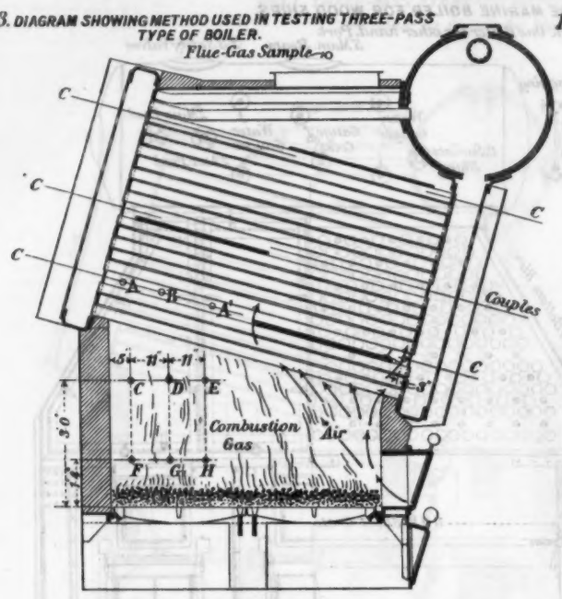



*Fig. 4.* DIAGRAM SHOWING FOUR-PASS TYPE OF BOILER WITH FACILITIES FOR INTRODUCING AIR OVER FUEL BED.

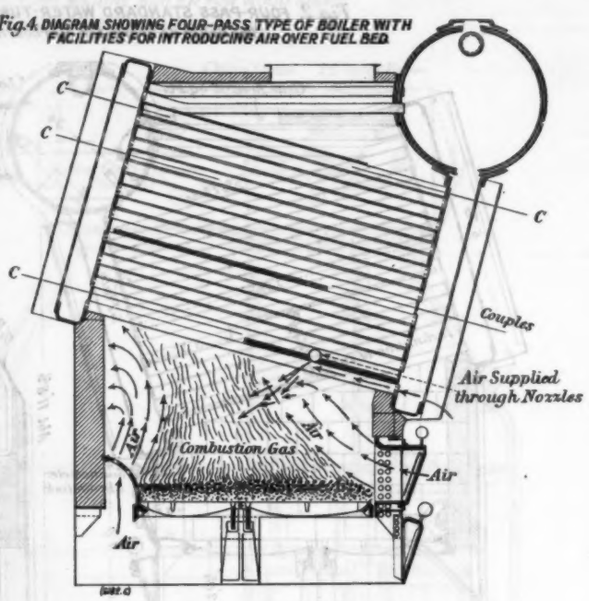
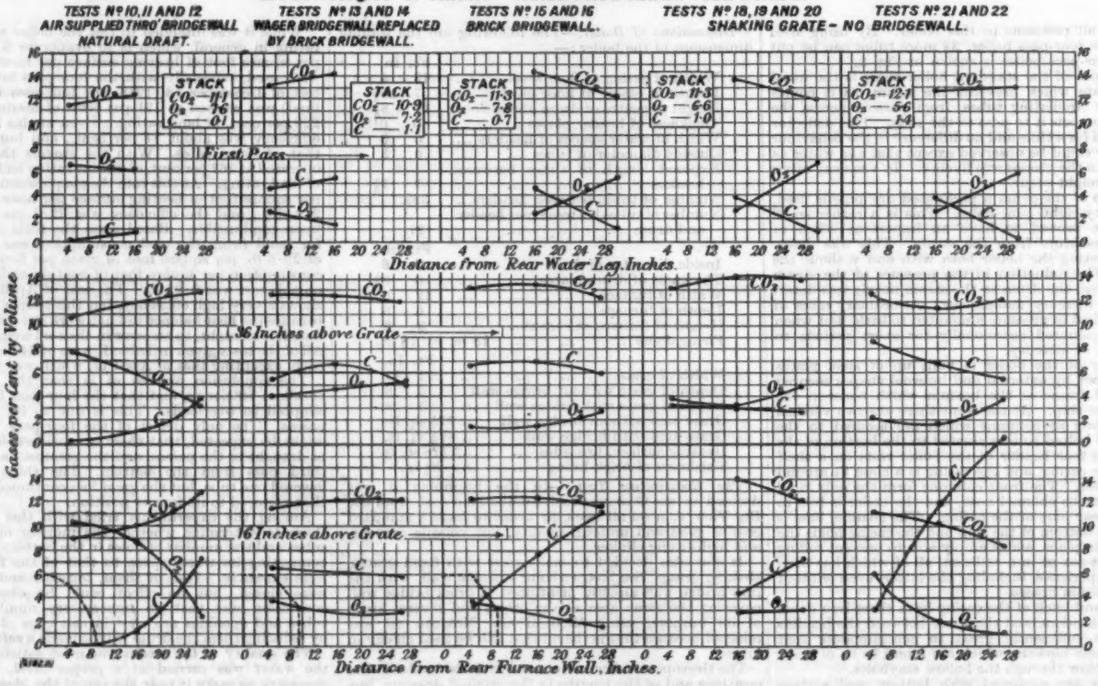



*Fig. 5.* COMPOSITION OF GASES IN FURNACE WITH VARIOUS METHODS OF INTRODUCING AIR OVER FUEL BED AND THE EFFECTIVENESS OF MIXING. THREE-PASS WATER-TUBE BOILER.


TESTS Nº 10, 11 AND 12 AIR SUPPLIED THRO' BRIDGEWALL NATURAL DRAFT.
TESTS Nº 13 AND 14 WAGER BRIDGEWALL REPLACED BY BRICK BRIDGEWALL.
TESTS Nº 15 AND 16 BRICK BRIDGEWALL.
TESTS Nº 18, 19 AND 20 SHAKING GRATE – NO BRIDGEWALL.
TESTS Nº 21 AND 22
STACK CO₂—11·1 O₂ — 7·6 C — 0·1
STACK CO₂—10·9 O₂ — 7·2 C — 1·1
STACK CO₂—11·3 O₂ — 7·8 C — 0·7
STACK CO₂—11·3 O₂ — 6·6 C — 1·0
STACK CO₂—12·1 O₂ — 5·6 C — 1·4
First Pass
36 Inches above Grate
16 Inches above Grate
Gases, per Cent. by Volume
Distance from Rear Water Leg, Inches.
Distance from Rear Furnace Wall, Inches.

for them. The points at which gas samples were collected are indicated by the small circles designated by the capital letters A, A¹, B, C, D, E, F, G, H and I.

*Admission of Air over Fuel Bed.*—During the first six tests a large amount of combustible gas passed out of the furnace and either burned at the base of the stack, causing high flue-gas temperature, or escaped unburned. It was apparent, therefore, that more air had to be admitted over the fuel bed and better means provided for mixing it with the combustible. Admission of air through the holes in the fire being undesirable because the size of holes cannot be controlled, a number of ½-in. holes were accordingly made in each firing door: the small opening in the first baffle at I was closed and the baffle extended, making the gas passage between the end of baffle and the rear water leg 36 in. This had the effect of causing the air admitted through the firing door to flow further to the rear of the furnace and thus facilitate better mixing with the combustible gases.

In addition to these changes, Wager's bridge wall was installed to supply additional air to the rear part of the furnace. See Fig. 4. The bridge wall consists of a large number of cast-iron bars placed against the rear wall of the furnace, and forms a structure similar to a plain grate. The air passes into the furnace through narrow slots between the bars, and is regulated by the thickness of the fuel bed near the bridge wall. The thicker the fuel bed the greater is the area of the air spaces covered with coal, and the smaller is the quantity of air flowing into the furnace. The air enters in a large number of thin streams.

With the air admitted through the firing door and through the bridge wall, the combustible gases rising from the fuel bed are squeezed between two streams of air coming in from two different directions and the mixing is greatly aided. The direction of the streams of air admitted over the fuel bed under these conditions is indicated in Fig. 4. The total area for admission of air over fuel bed was about 160 sq. in., or approximately 2 per cent. of the grate area.

*Mixing of Air and Combustible by Different Methods of Admitting Air over Fuel Bed.*—In order to determine the effect on the mixing and combustion of various methods of admitting air over the fuel bed, a set of six gas samples was taken in the furnace and two in the gas passage between the rear water leg and the end of the first baffle. The points at which these samples were taken are indicated in Fig. 3 by the small circles designated by the capital letters A to H. The analyses of these gas samples are shown graphically in Fig. 5.

*Analyses of Gas Samples shown by Diagrams in Fig. 5.*—Fig. 5 shows five groups of tests, each group being represented by one of the five vertical charts. The furnace conditions under which each group of tests was made are indicated by the label at the foot of each chart. Each of the three large squares in each vertical chart gives the samples taken at one elevation above the grate, *e.g.*, the lowest square gives the analyses of samples taken 16 in. above the grate.

The abscissæ of the lower two squares give the distance of sampling from the rear of the furnace wall; and those of the highest square give the distance of the point of sampling from the rear water leg. The ordinates give the percentage of the gases. The points giving the percentage of each gas at one elevation above the grate are connected by a smooth curve, principally to make the

TABLE I.—*Results of Tests of Four-Pass Boiler Equipped with the Two Type "B" Underfeed Stokers.*

| | April 8 | April 9 | April 13 | April 12 |
|---|---|---|---|---|
| 1. Date, 1919 | | | | |
| 2. Duration, hours | 24 | 24 | 22 | 24 |
| *Dimensions and Proportions.* | | | | |
| 3. Grate area, sq. ft. | 77·50 | 77·50 | 77·50 | 77·50 |
| 4. Heating surface, sq. ft. | 2,500 | 2,500 | 2,500 | 2,500 |
| 5. Ratio grate area to heating surface | 32·26 | 32·26 | 32·26 | 32·26 |
| *Average Pressures.* | | | | |
| 6. Gauge pressure, lb. | 199·00 | 199·00 | 197·00 | 198·40 |
| 7. Atmospheric pressure, lb. | 14·51 | 14·51 | 14·50 | 14·44 |
| 8. Absolute pressure, lb. | 213·51 | 213·51 | 211·50 | 212·84 |
| 9. Draught between damper and boiler, in. | 0·35 | 0·85 | 1·40 | 1·43 |
| *Average Temperatures.* | | | | |
| 10. External air, deg. F. | 47 | 53 | 50 | 44 |
| 11. Fire room, deg. F. | 61 | 68 | 63 | 62 |
| 12. Feed water, deg. F. | 66 | 67 | 66 | 63·40 |
| 13. Escaping gases, deg. F. | 535 | 591 | 618 | 659 |
| *Fuel.* | | | | |
| 14. Moist coal consumed per hour, lb. | 1,189 | 1,614 | 2,000 | 2,392 |
| 15. Moisture in coal, per cent. | 2·92 | 2·82 | 3·35 | 4·14 |
| 16. Dry coal consumed per hour, lb. | 1,155 | 1,568 | 1,933 | 2,293 |
| 17. Dry refuse per hour, lb. | 126 | 160 | 184 | 214 |
| 18. Dry refuse in per cent. | 10·90 | 10·20 | 9·50 | 9·30 |
| 19. Combustible consumed per hour, lb. | 1,029 | 1,408 | 1,749 | 2,079 |
| *Quality of Steam.* | | | | |
| 20. Moisture in steam, per cent. | 0·75 | 0·75 | 0·85 | 1·02 |
| *Heat Value of Coal and Efficiency.* | | | | |
| 21. Heat value of 1 lb. of dry coal, B.t.u. | 14,040 | 14,342 | 14,234 | 14,404 |
| 22. Efficiency of boiler based on dry coal, per cent. | 79·20 | 75·00 | 72·50 | 71·40 |
| 23. Efficiency of boiler based on combustible per cent. | 80·20 | 76·50 | 72·90 | 72·50 |
| *Water.* | | | | |
| 24. Water supplied to boiler per hour, lb. | 11,124 | 14,586 | 17,253 | 20,390 |
| 25. Dry steam generated per hour, lb. | 11,041 | 14,479 | 17,106 | 20,182 |
| 26. Factor of evaporation | 1·20 | 1·20 | 1·20 | 1·204 |
| 27. Equivalent evaporation from and at 212 deg. per hour, lb. | 13,249 | 17,375 | 20,527 | 24,299 |
| *Evaporative Performance.* | | | | |
| 28. Water evaporated per pound of dry coal, lb. | 9·55 | 9·23 | 8·87 | 8·80 |
| 29. Equivalent from and at 212 deg., lb. | 11·47 | 11·08 | 10·62 | 10·60 |
| 30. Water evaporated per pound of combustible, lb. | 10·85 | 10·21 | 9·80 | 9·66 |
| 31. Equivalent from and at 212 deg., lb. | 12·90 | 12·34 | 11·70 | 11·68 |
| *Rate of Combustion.* | | | | |
| 32. Dry coal burned per square foot per hour, lb. | 14·90 | 20·23 | 23·80 | 29·60 |
| 33. Dry coal burned per square foot heating surface per hour, lb. | 0·46 | 0·62 | 0·77 | 0·92 |
| *Rate of Evaporation.* | | | | |
| 34. Water evaporated from and at 212 deg. per sq. ft. h. s. per hour, lb. | 5·30 | 6·95 | 8·21 | 9·72 |
| 35. Water evaporated from and at 212 deg. per sq. ft. grate per hour, lb. | 170·90 | 234·20 | 264·00 | 313.60 |
| *Power of Boiler.* | | | | |
| 36. Commercial horse-power for land use, h.p. | 384 | 504 | 595 | 704 |
| 37. Excess above commercial rating of 250 h.p., per cent. | 54 | 102 | 138 | 182 |
| 38. Marine rating in water evaporated per hour from and at 212 deg., lb. | 15,000 | 15,000 | 15,000 | 15,000 |
| 39. Equivalent commercial horse-power of marine rating, h.p. | 435 | 435 | 435 | 435 |
| 40. Excess above or below marine rating, per cent. | 12 below | 16 above | 37 above | 62 above |

chart clearer. The analysis of the flue gases collected at the same time at the base of the stack is given in the small tables in the top squares. The location where the stack gases were taken is also indicated in Fig. 3.

The first group of tests gives the analysis of the furnace gases when the air over fuel bed was admitted through the firing door and through Wager's bridge wall. The chart is intended to show how the air admitted through the bridge wall mixes with the gases and affects combustion. The sample taken 16 in. above the grate and 5 in. from the rear wall shows practically no combustible gas, over 10 per cent. of free oxygen, and about 9 per cent. $CO_2$. The sample taken 27 in. from the rear wall shows about 7½ per cent. of combustible, only 2½ per cent. of oxygen, and nearly 13 per cent. of $CO_2$. Apparently at this level the oxygen admitted through the bridge wall did not have a chance to penetrate far enough toward the centre of the furnace to help in the combustion. The sample taken 36 in. above the grate and 5 in. from the rear wall shows less than 8 per cent. of oxygen, a trace of combustible gas, and nearly 11 per cent. of $CO_2$. At this elevation above the grate the sample taken 27 in. from the rear wall shows less than 4 per cent. combustible gas, about 3 per cent. of oxygen, and nearly 13 per cent. of $CO_2$. Comparison of the analysis of samples taken at these two elevations indicates that the air admitted through the bridge wall, in rising about 2 ft., has penetrated to a considerable depth into the stream of combustible gases rising from the fuel bed.

In the first pass the composition of the gases in the first 16 in. from the rear wall is nearly uniform, showing that the air admitted through the bridge wall mixed well with the combustible gases and did not pass out of the furnace in a separate stream. The stack gases showed, at the same time, 11·1 per cent. $CO_2$ and only 0·1 per cent. combustible, indicating a good combustion.

The second and third vertical charts give the analyses of gases of two groups of tests made with Wager's bridge wall replaced by a brick wall of similar shape, but having no provision for air admission. The shape of this brick bridge wall is shown by the dotted lines in the lower left-hand corners of the lowest squares. In both of these groups of tests the percentage of oxygen in the samples taken in the furnace is low, and the percentage of combustible gases is high, clearly indicating the lack of sufficient air supply. The stack gases of these two groups of tests contain a considerable amount of combustible, although the percentage of free oxygen is about the same as it was in the groups of tests made with Wager's bridge wall. Although the air found its way into the furnace it was not introduced close enough to the fuel bed to bring the combustion nearly to completion before the gases left the furnace. In the second group of tests the gases passed out of the furnace still containing about 5 per cent. of combustible, and in the third group they contained 3 per cent. of combustible gas. It should be noted, however, that in the third group of tests the samples collected in the first pass were taken farther away from the rear wall, and their analyses show the presence of the air admitted through the firing doors, the sample taken 30 in. from the rear water leg showing more free oxygen than the sample taken only 16 in. from it.

The tests of the fourth and fifth group were made with a shaking grate and no bridge wall of any description. The samples taken 16 in. above the grate indicate that a small quantity of air passed into the furnace close to the rear wall, but it was not sufficient to have much effect on the combustion. The percentage of combustible remained high even when the gases reached the first pass. In these two groups of tests the samples taken in the first pass 30 in. from the rear water leg show the effect of the air admitted through the firing door. The stack samples show over 1 per cent. of combustible gas and lower oxygen than either of the three previous groups. The lack of proper admission of air over fuel bed is clearly indicated in these last two groups of tests. The advantage of air admission through Wager's bridge wall was clearly demonstrated, and it was therefore used on all subsequent tests with hand-fired furnaces.

*Effect on Combustion of Different Methods of Admitting Air over Fuel Bed.*—In a similar way the effect on combustion of various methods of admitting air over the fuel bed was shown by means of tests made on the four-pass standard boiler of Fig. 4. The samples were taken similarly to those on the test with the three-pass boiler, the points at which they were taken being indicated by the abscissæ and the label in each square.

The first group of tests was made with the air supplied over the fuel bed, through the firing door, and through Wager's bridge wall. Sixteen inches above the grate the admission of air through the bridge wall was apparent only in the sample taken 5 in. from the rear wall. Samples taken 36 in. above the grate and in the first pass indicated fairly uniform distribution of the air but an insufficient quantity of it. Apparently during these tests the fuel bed near the bridge wall was carried too thick. Had a thinner fuel bed been carried the combustible in the first pass would have been much lower.

The second group of tests was made with the air over fuel bed being supplied with natural draught, through Wager's bridge wall, and through the firing doors, and in addition to this also under pressure of 2 in. of water through seventeen ¼-in. nozzles from a 3½-in. pipe placed between the first and second rows of tubes, as indicated in Fig. 4. The object of the air forced in through these nozzles was to force the air supplied through the firing door into the centre of the stream of combustible gas rising from the fuel bed and cause intimate mixing. The action of these nozzles is shown in Fig. 4. The samples collected in the first pass showed fairly uniform mixture and lower percentage of combustible than was obtained when the air was admitted only through the bridge wall and through the firing door. However, the amount of combustible was a little too high, indicating that not quite enough air was admitted.

The third group of tests was made with air admitted through the firing door, and with natural draught and air admitted through Wager's bridge wall under a pressure of ½ in. of water. In this case the air admitted through the bridge wall tended to flow in a separate stream close to the rear wall without penetrating very deep into the stream of combustible gas. The analysis of the samples taken in the first pass showed that the excess of air decreases as the distance from the rear water leg increases. On the whole, the admission of air through the bridge wall under pressure proved to be undesirable in this type of furnace. The tests represented by the second group showed conditions most favourable to complete combustion. However, the installation of the nozzles entails undesirable complications in boiler plants of ships. The conditions represented by the first group recommend themselves by their simplicity and effectiveness when attention is given to the proper thickness of fuel bed next to the bridge wall.

*Temperature Measurements.*—The temperatures were measured with thermocouples inserted into the setting through the hollow staybolts and moved across the gas passages, as indicated by the straight lines labelled "couples," or C, in Figs. 3 and 4. The temperatures were measured across the spaces between the ends of the baffles and the water legs.

## CATALOGUES.

*Electric Fittings.*—The general catalogue issued by British Insulated and Helsby Cables, Limited, of Prescot, Lancashire, recently noticed in English and Swedish editions, has also been issued in Spanish.

*Electric Switch Gear.*—The ironclad unit type of distribution board made by Messrs. Johnson and Phillips, of Charlton, London, S.E. 7, is explained in a catalogue which includes two-pole and three-pole units for use with single, two-core or three-core cables on low-tension circuits.

*Condensers.*—The Wheeler Condenser and Engineering Company, of Carteret, New Jersey, U.S.A., send a new edition of their catalogue dealing with surface and jet condensers, air pumps and cooling towers. A number of plants are shown, and the principles and methods of construction explained.

*Petrol-Electric Vehicles.*—Messrs. Tilling-Stevens, Limited, of Maidstone, have sent us several catalogues illustrating the application of their well-known petrol-electric transmission system to fire engines and commercial vehicles for both passenger and goods transport. In one case the petrol-electric generator is used to operate an arc-welding plant when the vehicle is at rest.

*Lead Burning.*—The Davis-Bournonville Company, of Jersey City, U.S.A., send a catalogue giving particulars of an outfit of tools and apparatus for lead burning, and also giving some instructions as to their use. Lead burning, like many other metal-fusing operations, is an ancient art or "mystery," which may, the writer of the catalogue suggests, be acquired by intelligent workmen who have proved their skill in the autogenous welding of iron and steel.

*Road Scrapers.*—A road "grader," so termed in the United States, is a road scraper carried on four wheels and pulled by an engine or horses, and somewhat similar to the ordinary snow ploughs. The machine made by Messrs. J. H. Adams and Co., Indianapolis, U.S.A., has adjustable leaning wheels to counteract the side pressure of the scraper on the vehicle. The wheels are set to suit the side slope of the road, or even to work on a steep bank. Messrs. Gaston, Limited, 20, Bishopsgate, E.C.2, are the agents.

*Electric Transformers.*—The Metropolitan Vickers Electrical Company, Limited, of Manchester, send descriptive and explanatory catalogues of single-phase oil-immersed furnace transformers; shell type, single-phase oil-immersed self-cooled transformers; three-phase core-type oil-immersed self-cooled transformers; and transformers for use in collieries. The latter are built low, and are mounted on rollers suitable for use underground. The company has also published an explanatory pamphlet on static transformers for use with electrical furnaces, written by Mr. J. Lindley Thompson, M.Sc., which will be useful to those in charge of furnaces for melting and refining metals, and in the manufacture of ferro-silicon, carbide, carborundum, &c.

*Mining Machinery.*—A very comprehensive and handsome catalogue of winding, hauling and pumping gear comes from Messrs. M. B. Wild and Co., Limited, Nechells, Birmingham. Single and double winding drums, main and tail haulage gear from 40 h.p. to 600 h.p., double and single hauling drums from 6 h.p. to 40 h.p., shipyard winches and capstans, and a series of smaller main and tail haulage gears are included. Among the pumping machinery listed are centrifugal pumps and plunger pumps of the horizontal, inclined and vertical types. All the machines are made to standards in a full range of sizes. Amongst the other machinery is an appliance for tipping the tubs of refuse from mines, a portable hoist for lifting heavy bars and joists, a straightening machine, a tube drawing press and some others.

*Steam Engines.*—A catalogue of steam engines made by Messrs. Newton, Bean and Mitchell, of Dudley Hill, Bradford, indicates that there is a strong demand for the larger sizes for mill and factory work. Horizontal compound engines with cylinders side by side or in tandem are listed in powers ranging from 200 h.p. to 2,400 h.p. The very large number of sizes made is remarkable; roughly one for every step of 50 h.p. up to about 500 h.p., and for every 100-h.p. higher. The piston-drop valve is now the favourite for these engines, though Corliss valve engines are also made. This firm also make a series of central exhaust engines, with single cylinder, in 15 powers, from 115 h.p. to 1,200 h.p., with piston valves, and recommend them for economy in steam and for prolonged non-stop work. All the parts are fully described and the catalogue contains some excellent technical and practical matter.

*Turret Lathes.*—A profusely illustrated catalogue of 48 pages quarto received from Messrs. Alfred Herbert, Limited, of Coventry, is practically filled with examples of the work done on the firm's turret lathes. The work may be said to represent almost every variety of turning work within the limits of length and diameter for which the lathes are suitable. Of course, with these machines the quality of the cutting tools, the method of mounting them and arranging the order of the operations are of the utmost importance. The lathes are very powerfully built, and every facility for rapid and easy handling is incorporated in them. They appear to be of four classes, each made in a number of sizes: (1) The combination turret with automatic feeds to cross saddle and hexagon turret saddle; (2) the capstan, which has a hexagon turret moving on a slipper and a cross saddle with hand feed; (3) the turret lathe, which has all tools, including cutting-off, fixed to the turret; and (4) the automatic, which is fully automatic for fairly complex turning jobs, except for chucking and unchucking the pieces.

# PHOTO-ELASTIC AND STRAIN MEASUREMENTS OF THE EFFECTS OF CIRCULAR HOLES ON THE DISTRIBUTION OF STRESS IN TENSION MEMBERS.*

By Professor E. G. Coker, M.A., D.Sc., F.R.S., K. C. Chakko, M.Sc., and Y. Satake, University College, London.

(*Concluded from page 264.*)

## Comparison of Stress Distribution in Perforated Steel and Nitro-Cellulose Tension Members.

The measurement of the stress distribution in a metal tension member having discontinuities involves very accurate observations of minute lateral strains, and a true measure of the sum of the principal stresses is therefore difficult to obtain, while the difference values cannot be obtained optically. We have therefore been content to measure this sum at various points, in order to show that these values agree with those obtained from optical material. The mean strain $E_{zz}$ in the direction of the thickness of a plate stressed in its own plane has a value given by the equation :

$$m\,E\,.\,e_{zz} = -\,(p+q) \quad . \quad . \quad . \quad (1)$$

where $m$ is Poisson's ratio, E is Young's modulus and $(p+q)$ is the sum of the principal stresses with reference to the line along which $e_{zz}$ is measured. The quantities $m$ and E do not change very much with different specimens of the same material, and are usually in the neighbourhood of 2·5 and 300,000 for nitro-cellulose, and 3·5 and 30,000,000 for steel, the units being pounds and inches.

In order to avoid exceeding the elastic limit of nitro-cellulose, it is advisable not to exert a stress of more than about 1,500 lb. per square inch, while for clearness of optical effect the thickness should not be more than ¼ in.

In the present examples this thickness is 0·18 in. approximately, and the maximum lateral strain at the limiting stress is − 0·002 in., corresponding to a lateral change of 0·00036 in. For an accuracy of 2 per cent. the extensometer must therefore be capable of measuring to an accuracy of seven mill onths of an inch. This is not difficult if temperature conditions are quite uniform, but for metals the conditions are more exacting, for although the stresses may be much greater without exceeding the elastic limit, the high value of E makes the lateral strain exceedingly small, thus for $(p+q) = 10{,}000$ lb. per square inch, the strain is $-\frac{1}{10{,}500}$ in., and the lateral change for a thickness of 0·5 in. is therefore $\frac{1}{21{,}000}$ in., or slightly less than five one hundred thousandths of an inch. If the same standard of accuracy is adopted as for nitro-cellulose, the extensometer must be capable of reading to an accuracy of about one millionth of an inch. It is therefore probable that in any comparison between nitro-cellulose and steel the measurements on the former are likely to be more accurate than for the latter.

In order to demonstrate that there must be agreement between results obtained from these different materials, it is probably sufficient to rely upon the fact that, on the usual assumptions of elastic theory, the fundamental stress equations contain no elastic constants.

Although no experiments have been made especially to prove that this agreement does exist here, it happens that the information for testing its substantial accuracy is available in the form of laboratory records made by a former Japanese research student, the late Y. Satake, who devoted a large amount of time and care during the session of 1914–15 to an investigation of the stress distribution in metal plates both below and above the yield stress.

In one of these experiments a steel bar was well annealed to remove initial stresses, and its physical constants determined in the usual manner. A specimen, 1·5 in. broad and 0·488 in. thick, showed a yield stress of 40,600 lb. per square inch, while the greatest stress it sustained before local contraction commenced was 57,000 lb. per square inch, and the total elongation at fracture was 23·4 per cent. on a gauge length of 8 in.

The modulus of direct elasticity E proved to be $30{\cdot}25 \times 10^6$ in inch-pound units, with a value of $m$ of 3·25.

A similar specimen was prepared by drilling a central hole ½ in. in diameter therein, and the lateral contraction at various points was measured under a simple tension load applied at a considerable distance from the discontinuity.

The strain readings recorded across the minimum section are shown in the accompanying Table VI for a load of 2·8 tons, corresponding to a mean stress of 12,850 lb. per square inch across the minimum section, and their stress equivalents are obtained from the equation (1) above, using the values of the constants already found from a simple tension experiment.

Mean stress at central section $= \frac{2{\cdot}8 \times 2{,}240}{0{\cdot}488 \times 1{\cdot}00} = 12{,}850$ lb. per square inch :—

$$p_m = p\left(1 + \frac{1}{c} + \frac{1}{2c^2} + \frac{1}{2c^3}\right) \text{ where } c = 3$$

$$= p\,\frac{38}{27} \text{ giving } p = 9{,}137 \text{ lb. per sq. in.}$$

The equivalent tension for a plate of infinite width is readily found, and by aid of Table VII the corresponding theoretical stress curve is determined, subject to the obvious correction that the cross radial stress $\widehat{r\,r}$ must vanish at the outer contour, thereby giving $\widehat{\theta\,\theta}$ as 9,815 lb. per square inch when $r = 3a$.

There are no experimental values on a plate of optical material which correspond exactly to this case, but those made with a ½-in. hole, in a plate 1 in. wide, give nearly the right proportions, except as regards thickness, but this dimension is not material, since all stresses and strains are averages in this direction.

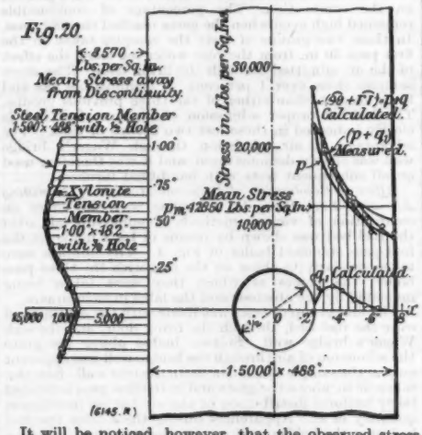
Table VI.

| Distance from Centre of Hole. | Lateral Train $\times 10^{-6}$ | $(p+q_1) = m\,E\,e_{zz}$ $= 98{\cdot}3 \times$ Lateral Strain. |
|---|---|---|
| In. | | |
| 0·256 | 232 | 22,800 |
| 0·266 | 227 | 22,310 |
| 0·320 | 205 | 20,150 |
| 0·376 | 179 | 17,600 |
| 0·476 | 147 | 14,450 |
| 0·576 | 114 | 11,210 |
| 0·676 | 105 | 10,320 |
| 0·710 | 92 | 9,040 |

For comparison purposes, the linear dimensions of the nitro-cellulose specimen are increased to make the holes agree in size, while the stresses are adjusted in the ratio of their equivalent tensions. The numerical values are recorded in Tables VII and VIII, and are plotted on Fig. 20. As will be observed, the agreement of all these curves is a remarkably close one, and the only serious difference occurs at the highest values for the steel tension member, where the curve of stress distribution bends over somewhat, in a way characteristic of over-stressed material.

Any error here is, however, probably due to an incorrect measurement of the exact position of the measuring needles with reference to the edge of the hole. The optical readings are somewhat higher than the theoretical value, but are not subject to this type of error.

Fig. 20.




It will be noticed, however, that the observed stress is rather higher than the limits which are stated to be desirable. Recent experiments, however, now in course of publication, appear to show that the linear law of stress optical effect holds well beyond the elastic limit of nitro-cellulose in tension, and is not a function of the strain. An additional check on the order of accuracy of the measurements upon the steel bar is afforded by comparing the mean stress exerted by the testing machine with the integrated stress area under the principal stress curve $p$. As the value of $q_1$ is unknown, its probable

Table VII.

| $\theta = 90.$ | $r = a.$ | $r = 1{\cdot}25a$ | $r = 1{\cdot}5a.$ | $r = 2a.$ | $r = 3a.$ |
|---|---|---|---|---|---|
| $\widehat{\theta\theta}/p$ | 3 | 1·934 | 1·519 | 1·219 | 1·074 |
| $\widehat{rr}/p$ | 0 | 0·346 | 0·370 | 0·281 | 0·148 |
| $\frac{\widehat{\theta\theta} + \widehat{rr}}{p}$ | 3 | 2·280 | 1·889 | 1·500 | 1·222 |
| $(\widehat{\theta\theta} + \widehat{rr})$ For $p = 9{,}137$. | 27,410 | 20,830 | 17,260 | 13,710 | 11,170 |
| | | | | $\widehat{\theta\theta} = 9{,}815$ | |

Table VIII.

Strain Measurements on Strait Contours.

| $x = -0{\cdot}75$ In. $y$ (In.). | Lateral Strain $\times 10^{-6}$ | $p = m\,E\,e_{zz}$ $= 98{\cdot}3 \times$ Lateral Strain. |
|---|---|---|
| 0·00 | 92·0 | 9,040 |
| 0·125 | 102·0 | 10,020 |
| 0·250 | 109·0 | 10,070 |
| 0·375 | 122·0 | 11,990 |
| 0·500 | 128·0 | 12,580 |
| 0·750 | 121·0 | 11,890 |
| 1·000 | 110·0 | 10,810 |

Table VIII.

Tension Stress across Minimum Section of Xylonite Tension Member 1·00 In. by 0·182 In., with Central Hole ½ In. Diameter.

| $x$ (in.) .. | 0·19 | 0·25 | 0·30 | 0·35 | 0·40 | 0·45 | 0·50 |
|---|---|---|---|---|---|---|---|
| $(p+q)$ lb./sq. in. | — | 1,260 | 1,050 | 870 | 700 | 610 | 590* |
| | — | 1,300 | 1,070 | 910 | 760 | 660 | 610† |

Steel Tension Member.

| $x_1$ (in.) .. | 0·253 | 0·33 | 0·40 | 0·47 | 0·53 | 0·60 | 0·63 |
|---|---|---|---|---|---|---|---|
| $(p_1+q_1)$ = $15{\cdot}28(p+q)$ | — | 19,250 | 15,940 | 13,300 | 10,700 | 9,320 | 9,015* |
| | — | 19,860 | 16,350 | 14,000 | 11,610 | 10,090 | 9,320† |

* Right side. † Left side.

Table IX.

Cross Stress Data obtained from a Xylonite Tension Member 1·00 In. by 0·182 In., with Central Hole $r = 0{\cdot}1875$.

| $x$ (in.) .. .. | 0·19 | 0·25 | 0·30 | 0·35 | 0·40 | 0·45 |
|---|---|---|---|---|---|---|
| $\frac{r}{a}$ .. .. | 1·086 | 1·43 | 1·71 | 2·00 | 2·29 | 2·57 |
| Mean $q$ lb./sq. in... | — | 193 | 150 | 85 | 35 | 18 |

Steel Tension Member.

| $q_1 = \frac{9{,}137}{598}\,q = 15{\cdot}28\,q$ | — | 2,950 | 2,290 | 1,310 | 535 | 275 |
|---|---|---|---|---|---|---|

Average error in measurement of $p = 3{\cdot}5$ per cent.

value has been calculated from experiments on the nitro-cellulose plate, Table VIII, and the ordinates of $q_1$, Fig. 20, have been subtracted to give the curve of stress intensity. It is then found that the average error $= \pm 3{\cdot}5$ per cent., and therefore shows a fair agreement. Additional evidence is afforded by the stress distribution along the sides shown in Table IX for steel and in Table X for nitro-cellulose, with equivalent values for steel for comparison. Both sets of readings are plotted in Fig. 20, and the agreement is there seen to be quite close, having regard to the slightly different proportions of the two members. It may be remarked in this connection that the measurements of the steel plate were made at various cross-sections when the existence of maximum stresses on each side of the minimum section was unsuspected, and although the evidence was plain, this fact had escaped notice until the optical properties were carefully examined recently.

Table X.

Tension alongside of Xylonite Tension Member 1 In. by 0·182 In., with Central Hole ½ In. Diameter.

| $y$ (in.) .. | 0·6 | 0·5 | 0·4 | 0·3 | 0·2 | 0·1 | 0·0 |
|---|---|---|---|---|---|---|---|
| $p$ .. .. | 700 | 780 | 790 | 770 | 700 | 610 | 570 |

Steel Tension Member.

| $y$ (in.) .. | 0·8 | 0·66 | 0·53 | 0·4 | 0·27 | 0·133 | 0·0 |
|---|---|---|---|---|---|---|---|
| $p_1 = \frac{9{,}137}{598}\,p$ $= 15{\cdot}28\,p$ | 10,700 | 11,920 | 12,070 | 11,770 | 10,700 | 9,320 | 8,710 |

Taken as a whole, this experimental test of the general theory of stress distribution in elastic materials may probably be considered to be a sufficiently close verification to warrant experiments on optical materials being accepted as applicable to engineering materials, subject to the limitations expressed and implied by the general theory of elasticity and the laws of photo-elasticity.

The effect of eccentric holes, groups of holes, riveted joints, and the like, affords an ample field for further investigation, and their great practical importance appears to warrant further photo-elastic investigation, since the simple cases cited here show that the stress distribution in more intricate members must be extremely complex, and that our assumptions in regard to them, although they may bear the test of practical work, are likely to be modified by experimental evidence of the nature and variation of the stress conditions.

In conclusion, the authors desire to express their sincere thanks to the Department of Scientific and Industrial Research for aid in the work, and to Mr. F. H. Withycombe for the construction of the models and experimental apparatus required.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, November 18, 1919.

## Electrical Plant for South Africa.

The office of H.M. Trade Commissioner at Cape Town has notified the Department of Overseas Trade that the Oudtshoorn Municipality invite tenders for the supply of the following electrical plant : Complete locomotive type steam set with generator and switchboard, or alternatively, boiler and auxiliaries, steam set with generator, condenser and auxiliaries, switchboard. Tenders, which should be sealed and endorsed on envelope "Tenders for Electrical Plant," and addressed to the Town Clerk, Town Office, Oudtshoorn, will be received there up to March 24, 1920. A copy of the specification and blue prints may be consulted by British firms interested at the Inquiry Room, Department of Overseas Trade (Development and Intelligence), 35, Old Queen-street, S.W. 1.